The Waterfront Construction Handbook

Guidelines for the Design and Construction of Waterfront Facilities

Maine State Planning Office
Maine Coastal Program
Augusta, Maine

January 1997

Public Access Series

The coast is one of Maine's most precious resources. The natural resources of Maine's lands and waters have supported generations of fishermen, clammers, and wormers. Half of Maine's population lives in towns along tidal waters where recreation and fishing provide jobs and a sizeable income to the State as a whole and to coastal communities in particular.

About 94 percent of the coast is privately-owned. Yet growing numbers of boaters, residents, tourists, and others demand more quality public access sites to the coast. Public access provides opportunities for people to reach the shoreline -- physically, visually or psychologically. Public access means different things to different people; a boat launch ramp for a sailor, a pathway for a clammer, a parking lot and pier for a commercial fisherman, or a coastal view for an artist. Because access needs differ, the means of providing public access opportunities will necessarily vary from one region to another and from town to town.

The parties responsible for planning and providing public access vary as well. For example, state or regional governments provide regional parks to accommodate large numbers of people. Access opportunities of a smaller scale may be handled more productively by local communities. Towns may be best suited to identify local needs and opportunities such as small public easements, town roads, private ways, or access arrangements with private landowners or developers.

Handbooks in the Public Access Series focus upon public access activities at the community level. They provide background information, technical instructions, and discussions of legal issues to assist towns in planning for, discovering, and providing public access opportunities to meet their needs. Handbooks available from the State Planning Office include:

***Coastal Right-of-Way Rediscovery Programs** A guide to how to discover rights-of-way that may already exist within a community.

***Liability** A guide to legal issues related to the liability of Maine municipalities and landowners providing public access ways for recreational uses.

***Planning and Implementing Public Shoreline Access** A guide to the steps involved in preparing a public access plan, and regulatory and non-regulatory techniques for securing public access sites.

***How to Conduct an Inventory of Scenic Areas** A step-by-step guide to mapping and analyzing a community's visual resources for future protection.

***Guidelines for Design and Construction of Waterfront Facilities** A guide to environmentally-sensitive design and construction methods for piers, wharves, bulkheads, seawalls, ramps, gangways, floats, and related landside facilities.

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Acknowledgments

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Section I.
Overview

Docks and piers are located all along Maine's coastline. These structures were once thought to be environmentally neutral, however, we now recognize that there is a cumulative impact from waterfront developments and associated structures such as docks and piers.

The term "cumulative impact" refers to the effect of many small incremental changes. To illustrate-- the construction of one pier may have a minor impact, yet the construction of six more docks or piers in the same small cove, each with their small impact on the local environment will have an overall cumulative effect on the wildlife, water quality and other natural resources of the cove that may be quite significant.

Most docks and piers are constructed for single-family use. For example, the Town of Yarmouth approved sixteen docks over the past five years. Only one was constructed for commercial use at a local marina, two were town landings for public access, one was part of a subdivision development for private recreational use, and twelve were private non-commercial piers or docks.

Erosion and sedimentation into the water during dock and pier construction may cause loss of marine habitat, alter the topography of the sea floor, or affect navigation and scenic character. Some activities such as boat refueling or discharge of sanitary waste and litter, sometimes associated with dock and wharf use, result in pollution that may harm marine life and even human health.

Pollution from these activities can be minimized by the use of Best Management Practices (BMPs). Best Management Practices that prevent erosion and polluted run-off are summarized in two manuals, Stormwater BMPs and BMPs for marinas and boatyards, available from the Nonpoint Source Pollution Technical Assistance Center at the Maine Department of Environmental Protection.

Careful consideration should be given to whether or not a project needs to be built in the first place. The best method of preventing adverse impacts to the environment is **not** to alter it. If a project is, after careful consideration, deemed to be necessary or desirable, then this handbook can be useful in minimizing adverse impacts.

Waterfront Construction Handbook

This handbook is intended to be used as a reference by municipal officials, private waterfront landowners, and others who need information about waterfront design, construction, and related permitting. This guide does not provide all the details needed by a marine contractor to construct facilities, but gives individuals overseeing contractors some guidelines by which to steer the project.

This handbook is not a substitute for the services of an engineer experienced in marine construction. This handbook presents information on the construction of docks and piers and other waterfront structures in a tidal environment. Some of the same recommendations may be applied to structures in freshwater environments.

Design and construction guidelines are presented for the following waterfront facilities: docks, wharves, and piers; bulkheads and seawalls, elevated ramps, walkways, and gangways; floats or platforms; and adjoining landside facilities. The best way to protect our coastal resources from the impacts of poor design and construction methods is to understand the importance of the natural environment and natural coastal processes and to design and construct a project in harmony with the local setting.

Section II of this handbook presents recommendations that illustrate how to design and build waterfront facilities in a low-impact manner likely to comply with permits. The next four sections (III to VI) provide specific details on design, materials and related items for constructing piers and wharves, bulkheads and seawalls, ramps or gangways, and floats. Section VII describes ways to minimize impacts of land-based facilities adjoining the waterfront site. The handbook concludes with Section VIII, a listing of sources for further information and financial assistance.

To ensure proper pier and wharf construction, the Department of Environmental Protection (DEP) has issued a set of criteria for piers and wharves under the Natural Resources Protection Act. These criteria or guidelines are included in Appendix I of this handbook, and should be consulted carefully. The DEP criteria were developed to make the permitting process more predictable for each applicant and to streamline the permit-handling effort for DEP staff. Any proposed project will continue to receive the appropriate level of environmental review.

Many waterfront projects will qualify for permits under the Permit-by-Rule program, a simplified application and review process as required by the Natural Resource Protection Act. Staff at the Department of Environmental Protection will let you know if your project qualifies for a permit under Permit-by-Rule (PBR). PBR-permitted projects are expected to comply with the guideline for pier and wharf construction in order to minimize impact on the local environment.

This handbook goes beyond the minimum DEP criteria to provide more comprehensive design guidelines. The following guidelines are not regulations. Instead they are intended to help individuals understand how to design, construct, and maintain a facility in an environmentally sensitive manner.

A final note........Town officials may find that a capital improvements plan can serve to link a public access strategy to the building of public facilities, such as town docks or piers.

Section II.

Suggestions for Optimal Waterfront Design & Construction

Waterfront construction practices can be substantially improved over those of the past, if project supervisors pay careful attention to the following general principles and practical suggestions. These will help minimize a project's impact on the environment as well as the project's lifetime cost.

A. USE DESIGN CONSULTANTS

☝ Seek professional advice regarding the proposed facility's structural safety, engineering design, longevity, cost-effectiveness, environmental impact, and storm and ice resistance.

☝ Take advantage of low-cost advice; not all consultants are expensive. Combine the talents of several marine contractors, a local user/engineer, an industrious retiree willing to do some investigating, or a State official. If you plan to hire a consulting engineer, check references to find a good one.

☝ Use other waterfront design and construction manuals to gain additional perspectives, or to help a consultant advise you. (See Technical and Financial Assistance, Section VIII. B.)

B. BUILD IT HEAVY

Why? The heavier a waterfront structure, the better it will stand up to ice, storms, and abuse.

How? Concentrate the weight by using fewer supports. Each support therefore must be heavier, which in turn increases its resistance to damage.

C. MAKE IT MAINTAINABLE

Many marine structures damaged or destroyed by storms or ice are already weakened because they have not been maintained, which can be expensive and difficult to plan or fund. Design structures for easy maintenance, and develop a maintenance plan. Structures are more easily maintained if they are built with materials that are easily understood and handled and if the materials are readily available from local vendors.

D. USE INEXPENSIVE MATERIALS

1. Economy = Low Impact

In many cases, materials with less impact on the ecology of the shore also are cheaper: stone or gravel is cheaper than bituminous paving; native green lumber is cheaper than pressure-treated; and tumbled ledge is cheaper than concrete.

2. Use Natural Wood When Possible

Of the available untreated woods in Maine, oak makes the strongest, most marine borer-resistant piling. Among the common native woods, hemlock is recommended for timbering. Spruce has a high strength per unit of weight, making it best for removable ramps and hand-movable floats.

3. Avoid Use of Treated Woods

Avoid pressure-treated material which contains toxic materials. **Do not use wood treated with pentachlorophenol or creosote, which is highly caustic as well as environmentally hazardous. Permits will not be granted for use of this type of treated wood in new construction.** For a structure primarily built with inexpensive native woods, portions that will be particularly rot-prone or inaccessible can be chromate- or arsenate-pressure- treated.

4. Do Not Use Preservative Coatings

No paint, stain or preservative should be applied to the surface of structures. All coatings pose a local environmental threat, damage flotation materials, and have only minimal affect on a structure's longevity.

5. Build an Open Structure

Air is cheap. Use an open structure to stretch materials, allow air circulation, and minimize trapping moisture that leads to rot. For this reason, do not use compound or laminated (sandwich) construction unless the wood is pressure-treated.

6. Metal

Metal structures corrode, are unsightly when old, and are difficult to properly dispose of when retired or badly damaged. Aluminum must be of a high-quality anodized type (which is expensive) if used near salt water. (For ramps, see section V. A. 3).

E. KEEP IT SMALL

Use three factors to determine dimensions: intended uses, cost, and environmental impact. This will tend to minimize project size. (See specific sections of this handbook and other publications listed under Technical and Financial Assistance, Section VIII. B.) Building the smallest practical structure possible will minimize the area of wetlands disturbed by construction (See H. below).

F. USE LARGE FASTENINGS

1. Diameter

Large diameter rods, pins, and bolts last-longer in waterfront construction. For example, 5/8-inch diameter bolts last twice as long as 16 d nails. Rust causes fastenings to thin, allowing waterfront structures to become loose and eventually wrack or split.

2. Materials

Some rust-resistant materials, such as aluminum or stainless steel, are too expensive to be cost-effective. Hot-dipped galvanized fastenings are the best buy. Electro-plated "galvanized" are not recommended because the protective layer does not last.

G. USE LOW-IMPACT DESIGN

1. Floats

Build temporary floats where possible. Temporary, movable structures like floats have less impact than permanent, fixed structures. Larger floats can be combined with smaller fixed structures to obtain the same space as a fully-fixed structure, with less impact.

Add feet or runners to floats. Floats with feet or runners smother less living matter than flat-bottomed floats.

Use moorings to anchor floats. Moorings have less of an impact than pilings, hold floats better, and cost less. Moorings made of blocks of dense concrete or granite can be put in place on the bottom without a crane, using a float or boat. Moorings can also consist of pins, set in ledge with a rock drill.

2. Pilings

Clustered pilings have less impact and are more maintainable than cribs (see Section III. B. 3).

3. Cantilever Structures

Cantilevers are supported on shore and extend over water or a tidal area. They resist ice better and impact the environment less than structures supported along their whole length or width (See B. above, and Section IV. C. 2).

4. Contour Shapes

Contour-following designs (as opposed to rectangular shapes that primarily protrude outward from a shoreline) can sometimes increase usable space while appearing less obtrusive.

5. Minimize Lighting

Lighting should be minimized and directed downward to avoid impairing navigation.

H. MINIMIZE CONSTRUCTION IMPACTS

1. Dredging

Avoid or minimize dredging. Dredging disturbs estuarine habitats, requires additional state and U.S. Army Corps of Engineer permits, and is expensive. It is less costly to use a string of floats to access deep water.

2. Salt Marsh

Avoid construction over salt marsh. Confine construction to ledge areas if possible. If salt marsh must be crossed, minimize the area of supports, and block as little light as possible by leaving wide gaps in deck planks.

3. Wetlands

Avoid disturbing wetlands, whether temporarily or permanently, from site preparation and construction through ongoing maintenance. Follow state permit conditions and consult with local Department of Marine Resource area biologists to facilitate greater public acceptance, lower cost, and minimum aesthetic interference with the natural or historic shore. Most facilities can be built without using construction equipment within the intertidal zone, and in some locations, permits will not be granted for projects proposing equipment use in that zone.

4. Mitigation

If wetland area will be destroyed or altered during construction, the permit holder may be required to mitigate the impact by restoring, creating or enhancing wetland. Contact the Maine Department of Environmental Protection for more information.

5. Marine Resource Areas

If possible, schedule construction for winter months in order to lessen the impact on intertidal ecology. Avoid construction in areas that may impact shellfish habitat and harvesting.

6. Debris

Clean up continuously during construction. Your community will appreciate your effort and the adjacent waters will be clear of your debris.

I. GAIN LOCAL SUPPORT

1. Group Facilities

Consider the construction of facilities that serve groups of people, such as a town dock, boat launch, or a single water access facility for subdivisions in coastal areas. Lower cost per user makes a higher quality structure more affordable.

2. Municipal Standards

Communities may want to consider regulating the allowable size and proximity of structures through local shoreland zoning ordinances. Local planning boards are encouraged to contact the State Planning Office for model standards for docks, piers, and wharves.

3. Conservation Groups

Ask local conservation commissions, marine resource committees, or other groups for an informal, non-binding review of your plans. With them as your supporters--or at least not as adversaries--every step of the process will go more smoothly.

4. Access

Provide legal access in perpetuity for all intended users.

Notes:

Section III.

Piers & Wharves

With proper design, piers can have a minimal impact on the shoreline. This section provides details on building piers, wharves, and docks to be useful, durable, and to have a minimal environmental impact.

A. SIZE & SHAPE

To limit the impact of piers on the environment, minimize the project dimensions: length, width, shape, and height.

1. Length

Measured from high ground to deep water, pier length should be sufficient to allow watercraft access at all tides, but not protrude into navigable water. Precise interpretation of this principle will vary with location, and is best determined by discussion with all interested parties. The pier should extend directly toward deep water.

2. Width

For structures that must extend perpendicular to the shoreline, narrow widths are preferred over wide ones, to leave as much adjacent shoreline as possible for other uses, or undisturbed in its natural state. Fixed pedestrian walkways can be perhaps 48 inches wide or less, exclusive of external bracing and rails, provided any ramps or other gear fit on the pier for winter storage. Twelve feet is wide enough for truck traffic and recommended only for commercial or public piers. Wide piers also may be appropriate when serving commercial marine enterprises or a large population.

3. Shape

The best shape for most structures is a long, thin rectangle, or a T-shape if extra edge space is needed for boats at the outer end. Fixed piers also work well if wider at the outer end, providing needed space with a narrower walkway. A good width is 63 inches at the outer end and 48 inches for the rest of the walkway.

4. Height

The runway over the intertidal or salt marsh zone should be as high as possible, not less than 5 feet except at the innermost end where it converges with the upland above the high tide line. This height is important to maximize light for growth of salt grass, but it also protects piers from storm damage.

This height can be achieved and still leave the outer end at a convenient height above the water, if the fixed runway is sloped so it is higher at the land end. This also makes the pier cart- and handicapped- accessible because it eliminates stairways down to the pier from high ground.

5. Seasonal vs. Permanent

Seasonal installations are preferred over fixed piers and wharves because (1) they have less impact on estuarine resources since they are removed during the off-season, and (2) they are less vulnerable to winter storm and ice damage. Therefore, use a design with a small fixed portion and removeable ramps and floats.

B. DESIGN

Pier design features that are also important include method of support, weight (for durability), structural reinforcement, and surface treatment.

1. Piles or Posts vs. Bulkheads

Open, pile- or post-supported structures are preferred over filled bulkheads by permitting agencies because they impact the intertidal zone to a lesser degree. Open structures require more maintenance but can be designed for easy maintenance by avoiding the use of cribbing supports, and using locally available materials.

Filled bulkhead piers are only justifiable when environmental impact is demonstrably low and demand for very heavy use and great permanence makes them worth the extra cost for extremely high-quality permanent construction and maintenance. They are more likely to be allowed if built over a stone beach or ledge.

Designing a filled bulkhead for easy maintenance is difficult. The most maintainable design uses walls of a highly permanent material such as granite blocks or high-density, low-moisture concrete, strongly tied together. For further guidelines on building bulkheads, see Section IV, especially parts A.5, B.3 and B.4.

2. Adding Weight

Weight is particularly important in fixed piers. The heavier the structure, the better it survives storms, ice, or misuse by users.

Platforms--Do not use cribs filled with stone to achieve weight. Instead, use a platform loaded with

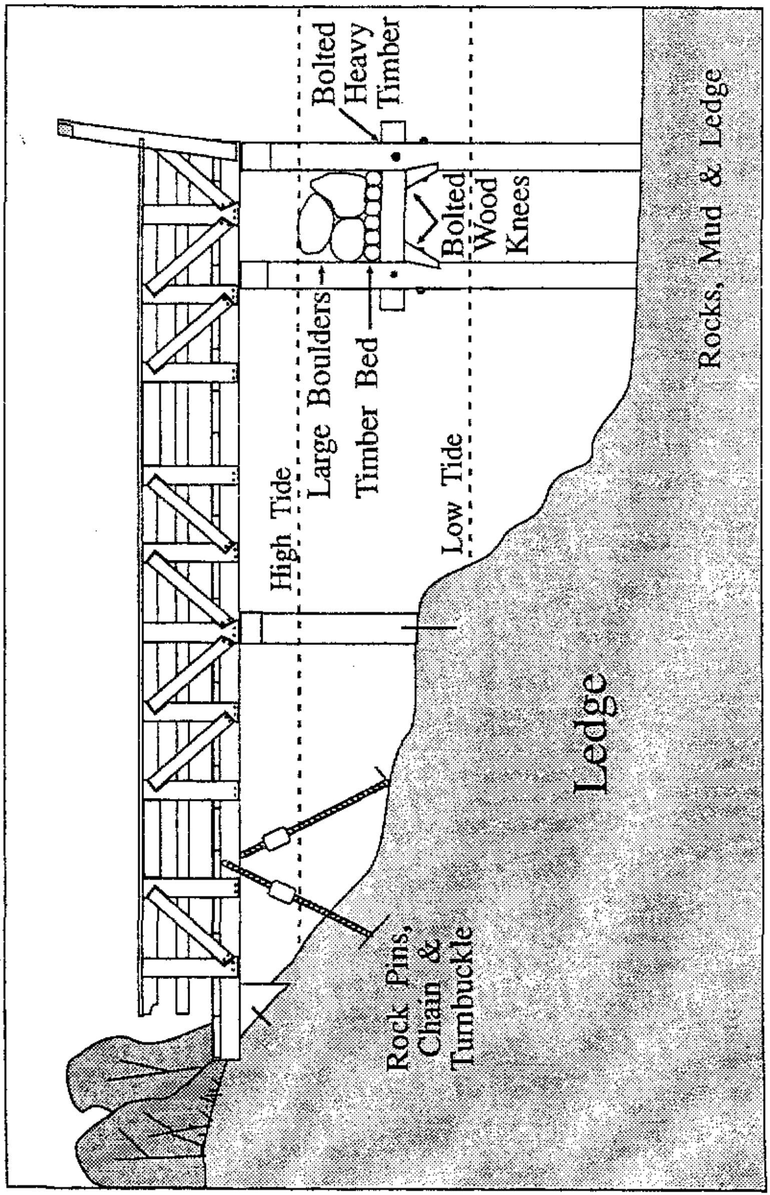


FIGURE I: Two ways to secure a fixed pier

rock or filled with concrete to accomplish the same goal (Fig. 1). Locate it above the low tide line so that its components can be inspected, repaired or replaced. This design concentrates the weight on few points of support, further increasing the structure's sturdiness (see Section II.3 above).

Chain and turnbuckles--Another good way to secure small piers is by adding chain and turnbuckles for weight (Fig. 1). Firm ledge above low tide level must be available for attaching the pins. Turnbuckles should be kept above high water and greased with waterproof grease. Do not use cable; it will rust away too quickly to be cost-effective. If the turnbuckles are kept tight and the chain is pinned securely to the ledge, a chain adds the equivalent of several tons of weight to the pier.

3. Leaving Open Spaces

Concentrate pilings or supports in clusters or rows with open space between them. This makes maintenance easier and allows natural water flow, which avoids trapping debris or ice. Make the open spaces large, at least 10 feet long towards the water, or 20 times the diameter of the supports.

4. Securing Pilings

In ledge--Piling supports need to be pinned securely to ledge above low tide level where available (Fig. 2). They can be pinned below low tide, but this is expensive, requiring a diver and special equipment. It is sufficient to set or drive pile tight into the ledge, particularly if the pier is heavy.

Without ledge--Where ledge on shore is not

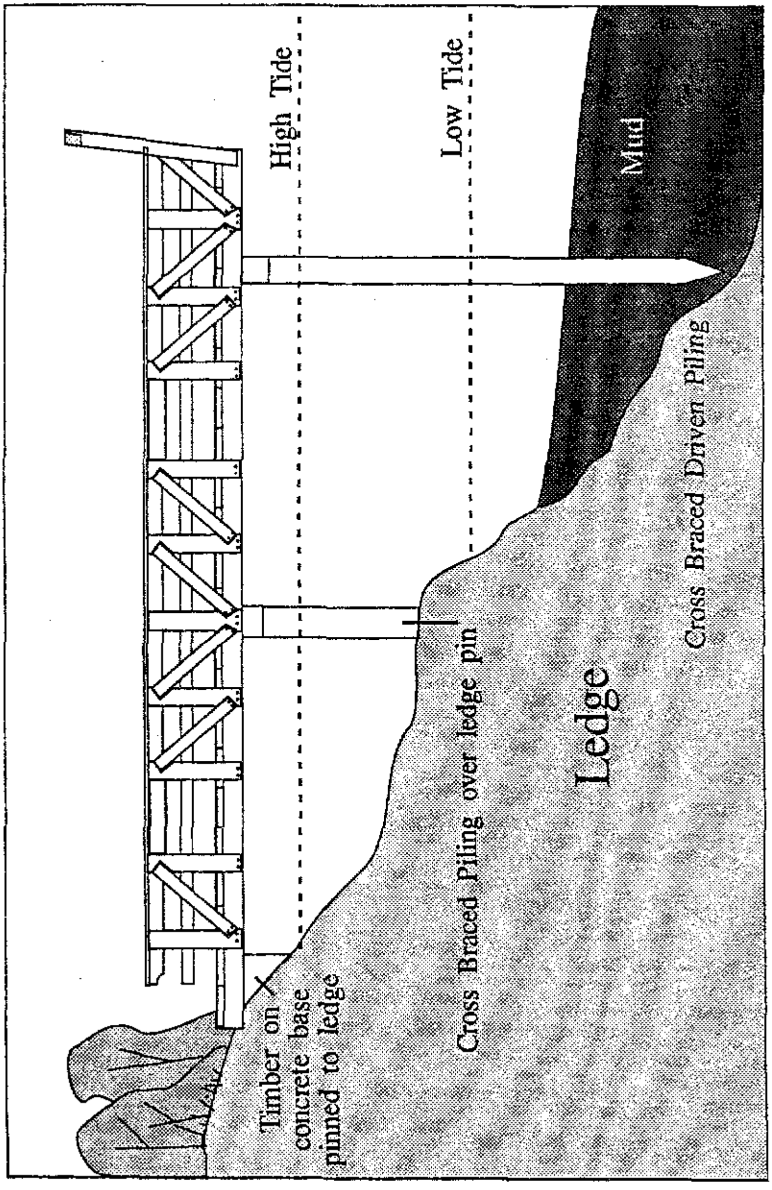


FIGURE 2: Typical ways to secure pilings of piers

available, pilings should be driven into ledgy bottom, even if only a few inches deep, to assure they are firmly footed (Fig. 2). If the bottom is soft material such as sand or mud, pilings should be driven in until they refuse to go any further. Jetting pilings rather than driving them is not recommended, because it disturbs sediment and clouds the water. Particular care should be taken in this regard near lobster or fish pounds or swimming areas.

5. Trusses

Span the spaces between supports with strong materials, made stronger by trussing (placing diagonal braces in an open design). Trusses can be attached above the deck under the handrails, as in Fig. 3.

Place each trussing part according to its function: determine whether the normal force on the truss will be pushing (compression) or pulling (tension). On those parts that will be normally compressed, use butt joints, so that the braces push directly against other structural members. For those parts normally under tension, you must rely on bolts. Use as many as the wood will take and place them carefully to avoid splitting.

6. Decking

Decking with wide gaps between boards (¾-inch or more; a 1-inch gap is good) is better than tightly-spaced decking for two reasons: (1) it allows air to circulate, preventing debris build-up and moisture trapping that leads to rot; and (2) it allows direct sunlight to reach marine and shoreline estuarine vegetation near the structure.

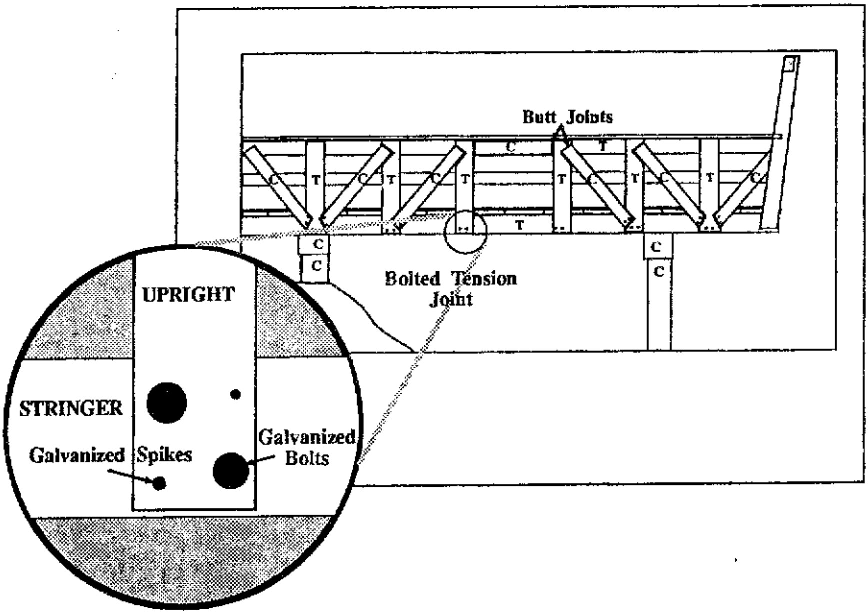


FIGURE 3: A trussing
(T=Tension C=Compression)

7. Intertidal Equipment Use

Work with a builder to assure the structure can be built without using equipment in the tidal zone. Usually it is cheaper to build out from the shore in sections, with equipment resting on the newly completed work to build the next section. Both permitting and public acceptance are more likely without intertidal equipment use, and construction is not delayed by tides.

C. MATERIALS

Piers can be constructed of wood, steel, aluminum (rarely), or concrete. Each material has its value and problems.

1. Wood

Wood is preferred because it is locally available, inexpensive, easy on nature, and workable without special equipment. (See Section II.b for wood type and treatment.)

2. Steel

Steel, although strong and heavy, is subject to corrosion breakdown. Provision should be made to minimize rusting and ensure that each member can be replaced or recoated easily.

Coatings should be applied only after reading state regulations. Control of sprayed matter is extremely important. Many coatings are of doubtful cost-effectiveness. Two-part epoxy coatings are good but very expensive. They also require warm weather for application, and in some locations it is unwise to use them in warm weather because of pollution and health risks as well as regulations. Coal tar epoxy is one coating of established reputation.

No thin steel should be used. Even 3/8-inch is too light; one layer of rust and little is left. The smallest cost-effective thickness is probably 1/2-inch, unless expensive coatings are not only applied at the start but carefully and continually touched up. Steel gussets and corner pieces, even when galvanized, are usually too thin to last. If you go to the trouble to have such hardware made, remember that it is not quick or simple to do so; make them heavy enough to last, be sure they are galvanized by the hot-dip method, and make several extras for replacement or later addition.

3. Aluminum

Aluminum is usually too expensive to be cost-effective. For fixed piers, its light weight is also a disadvantage.

4. Concrete

Concrete is undervalued as a waterfront material, and certainly suffers from a bad reputation because so much concrete work is poorly done. Concrete can be used safely on piers only if it is dense (low- moisture) and highly reinforced. Follow carefully the guidelines for using concrete in the section on bulkheads below, Section IV.B.3.

Concrete decks poured on fixed piers are valuable if very heavy vehicles are to use the pier. The concrete will eventually crack, making reinforcement rods very important The rods should be totally encased in concrete, not just laid in the bottom. The best reinforcing is horizontal, near (but not on) both top and bottom, and crossed in every direction.

Support posts or walls of concrete require even more careful mixing and placement than a deck top to ensure strength and longevity.

Moisture content in the concrete should be extremely low, or freezing and salt-water action will crumble it. Water in concrete should be used up in rehydrating the powdered stone, leaving little or none to form moisture pockets that can freeze or allow in salt water (see Section IV.B.3 below). To settle the mix, use vibrators, but sparingly.

Placement below water --Very low moisture concrete can be placed in the intertidal zone at low tide (if the necessary permits have been obtained), because the concrete will set enough to keep water out before the tide comes in.

Notes:

Section IV.
Bulkheads & Seawalls

Bulkheads and seawalls used for shoreline erosion control are expensive, generally ineffective over the long term, and difficult to maintain. Such structures, intended to prevent undercutting of shoreline buildings, often move the problem to adjacent property. Technical improvements have lessened these disadvantages, but bulkheads remain among our more desperate measures.

For these reasons, state regulations discourage building new bulkheads and seawalls. Attempts to stall the natural process of erosion with man-made walls must be undertaken only with careful thought. If possible, use plantings to stabilize eroding shores.

A. DESIGN

Hard experience with structures that fail over time has resulted in the following design guidelines that provide longer structure life with less maintenance and environmental impact.

I. Vertical vs. Sloped

The first decision in both new and repair work on bulkheads and seawalls is whether to build them vertically or at a slope. Sloped walls usually make for better erosion control and cost less, sometimes much less. Many shore owners find they can do without the lost horizontal shore space, or recreate it by adding a cantilever or open deck (see Section IV.C. below). Generally, gentle slopes are best; those of 45 degrees or less allow most material to rest naturally on the slope without mechanical tie-backs.

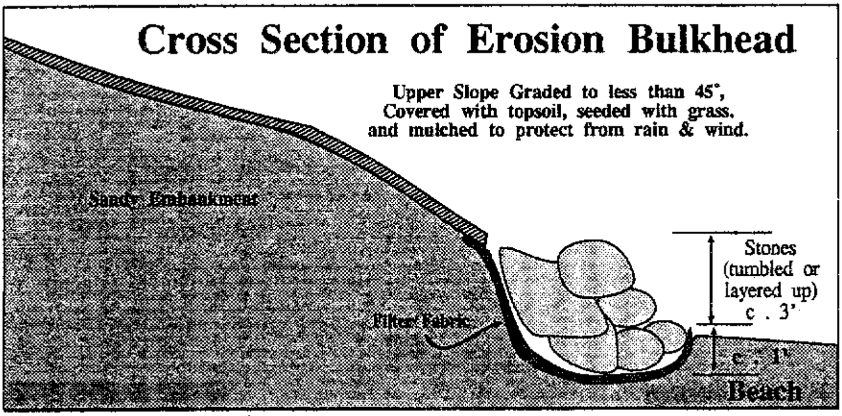


FIGURE 4: Bulkheads

2. Base

The bottom three feet of a bulkhead or seawall are very important. This section is where water from underground seepage and/or tidal action removes material. Some successful erosion control structures involve only the bottom portion (see Fig. 4).

3. Securing the Base

To secure the bottom edge when the wall or bulkhead sits on ledge, pin it with steel rods large enough to last many years--at least 1 -inch diameter. When the wall sits on softer material such as sand, clay, or loose rock, dig down at least a foot (three feet is best) and start the wall there, so storm water cannot work under the wall. The more storm exposure, the deeper the foot of the wall should be buried.

4. Retaining the Fill

Use filter cloth (also called filter fabric or geotextile, a synthetic sheet material designed to be buried), as a liner to allow the free flow of water through the fill while retaining all the fine particulate matter. Without it, many bulkheads fail to hold their fill, particularly along edges and in corners, where the fill finds passage out and leaves caved-in areas.

Filter cloth is usually inexpensive, and the cheaper types are adequate for bulkheads. The material should be well anchored, completely shielded from light (which decomposes it), and located at the line between coarse and fine materials (Fig. 4). Usually this means placing a layer of coarse material such as boulders and rocks on the water side of the cloth and clay or gravel on the land side.

5. Anchoring

Strongly anchor back all vertical bulkheads. Any wall steeper than 45 degrees needs anchoring. Outward pressure is always great, especially in wet weather and with fine fill.

Avoid the old conventions of tying back structures; either steel cable tied to aburied "dead-man" of wood or concrete, or (for cribbing) wood timbers pinned to a second inner buried wall. There is nothing wrong with a buried inner or dead-man wall, but wood rots and cable quickly rusts. Even galvanized cable will only last a few years where it is exposed to air and water among the rocks and soil in which it is buried. Typically when such a cable fails, all of it is found to be in good condition except some small section that completely rusted away because of exposure, often near the back side of the bulkhead. If you must use cable, use it only in proven low-exposure areas that are deeply buried or covered by waterproof material.

A better solution, rather than using steel cable, is synthetic cable, which will never rust, or heavy steel rod that will rust slowly. Use better material where deterioration is most likely. For example, as in Fig. 5, specify 1 -inch hot-rolled steel rod in general and use 2½-inch for the four feet closest to the bulkhead.

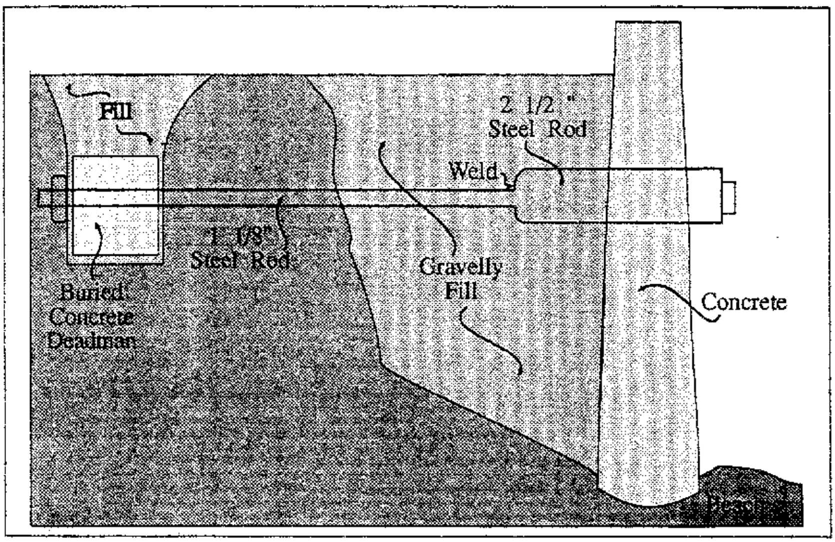


FIGURE 5: Cross section of anchored vertical bulkhead

Remember that the cables or rods will be buried and must be dependable for holding the bulkhead. If they fail, the whole expensive bulkhead will begin to break up. A common mistake is relying on too little to tie back a bulkhead. This is the worst place for economizing.

6. Size and Cost

Keep dimensions small. Here is where economizing pays: the smaller the bulkhead project, the easier it will be to get permits and to pay for it. Generally, bulkhead walls are surprisingly costly. Most bulkheads cost 50 to 100 percent more than anyone expected when the project began. Careful design that focuses the project where it is most needed (see 2. above), will help. Keeping it cost-effective as well as erosion-effective is a job for both designer and builder.

7. Cribbing

Don't crib. Wood cribbing is a poor way to build a bulkhead. It is expensive and short-lived, unless made of pressure-treated wood (or concrete logs). The buried back half of a crib will soon begin to rot. After eight to twelve years, significant deterioration will occur. To use pressure-treated wood (surface-treated wood lasts no longer than untreated), you will have to obtain permits for burying large quantities of toxic materials that are in the wood.

Wood cribs also suffer from the following:

Insufficient fastening--The ½-inch rebar (reinforcing steel rod) often used is not likely to last the 20-30 years people hope for in a seawall. Instead, use hot-dipped galvanized pins of ¾-inch diameter or larger, or use hot-rolled steel of 1-inch or larger.

Insufficient tie backs--A wood crib should use at least 1¼ times the wood necessary to cover the surface involved. Half the wood is used in the open front and back wall and the other half in tying the two together. A wall with fewer tie-backs will lose its shape sooner.

Undersized rock fill--A crib must be filled with stone larger than the openings between timbers of the front wall. For example, a wall with 6-inch spaces between timbers requires 8-inch minimum stone. Though stone is expensive, don't skimp on either its size or quantity.

Insufficient time and money for site restoration and clean-up--Moving rock fill on to the site to put into a crib often means crossing lawns or gardens which must then be rebuilt. It is common to choose cribbing over other designs to save destructive access procedures, but it is a mistake. Reaching tumbled stone or concrete bulkhead with materials may prove less destructive.

B. MATERIALS

For the sake of the life of the bulkhead or seawall, plan to use highly permanent materials such as granite blocks or riprap tumbled stone. Avoid materials like wood cribs and light steel that suffer from creeping decay. (See also Section II above, especially parts D and F, and look for advice in other manuals.) **Stone riprap that is keyed into the bottom is the 'hard' material least damaging to the shore environment and preferred over concrete or steel seawalls.** Where feasible, vegetative plantings should be used to to reduce shoreline erosion.

1. Wood

Wood is most popular material to use because it is inexpensive. You must, however, choose between using toxic materials (in wood preservatives) or risking a shorter project lifespan. The first may pose environmental impacts, the second is not cost-effective. On the other hand, wood has great aesthetic appeal. If you use wood, try to design a maintainable structure with maximum air circulation (large stone) behind the wood. Some vertical stone/wood bulkheads are maintainable because a portion can be replaced (or covered with a layer of new wood) without rebuilding everything. Wood cribs are notoriously non-maintainable.

2. Steel

Bulkheads of driven piles last 20-30 years if made of heavy steel. Disadvantages include initial high cost and an industrial, urban appearance. Minor defects can be corrected with welding but otherwise these bulkheads cannot be maintained. Therefore, it is very important to use steel more than -inch minimum thickness to assure long life. Coatings may help lengthen lifespan a little.

3. Concrete

Typical house foundation concrete is not good for marine or lakefront bulkheads (or piers) because it is under-reinforced and mixed too wet. But properly mixed and positioned concrete can be excellent, durable, long-lasting, cost-effective, and environmentally clean. The following guidelines will help ensure this result.

Use low water content--most concrete contains too much water, reducing its strength and resistance to freezing-induced breakdown, saltwater-induced disintegration, and surface crumbling. These qualities shorten the life of concrete; the difference in water content separates good concrete that lasts 50-100 years from poor that lasts 2-10 years. A little attention yields large rewards.

To test water content, use a **slump test**. Concrete suitable for marine bulkheads should never be soupy. It must have less than 3 inches of slump, which means that the water content is so low and the mix so stiff that a cone a foot high only loses 3 inches when the form is removed from around it (like an upturned sand pail at the beach). Take this limit seriously: the ideal slump is only 1 inch, a tolerable compromise 2 inches.

You must fight for dry mix. Whether mixing concrete yourself or ordering a truckful, it is easy to add too much water. Truck mixing and barrel mixing seem to require more water to make the sand and cement powder smooth out than you can tolerate. But with practice and insistence, you can get a 1½-inch, if not 1-inch slump from a barrel mixer or truck.

Pumping concrete into a marine bulkhead works and is cost-effective when trucks can't reach the site or the cost of repairing the roadway they would use exceeds that of pumping ($500 to $700 in 1990 around Portland).

Pumps can deliver a stiff mix as far as 110 feet by boom, or 1500 feet by hose. Shorter distances (around 50 feet or less) can be crossed by less expensive conveyors. Whatever method is used, the truck operator will try to persuade you to tolerate a wet mix, but do not give in. A good operator can move mix with 2-inch slump without plugging up equipment.

Use vibrators sparingly--Properly dry concrete mix doesn't flow conveniently into corners and along surfaces of forms to make a neat, professional- looking project, and must be forced past the large amounts of reinforcement required for high-strength marine structures. For this purpose, a vibrator, usually the pencil type, may be used.

However, a vibrator may also ruin the mix by separating water and aggregate, leaving some of the form filled with all rocks and other parts all water. To avoid this problem, the vibrator must run for only about one second in each cubic foot of mix. Any longer in one spot and separation begins immediately. It is better to leave a few incompletely filled corners or surfaces than suffer serious weakening from material separation. Because of this, the professional-looking job may be the weaker one. Workers are often afraid to do the job right because it might not look right.

Use tapered form shapes or other well-engineered designs, rather than a simple set of parallel walls as in a house footing. Tapered forms can be built as cheaply as house footing forms, but they put strength where it is most needed, near the bottom of the bulkhead, and use less mix to do the same job. A tapered shape is also less likely to buckle or distort.

Long, straight bulkheads should be generously tied back so neither top nor bottom will kick outward with the inevitable strong pressure from behind.

Reinforce heavily--Use large quantities of reinforcements keeping them well inside the concrete--but not too far inside, since reinforcing placed in the center is not as strong. The ideal location is an inch or two inside each surface.

Use fairly large-diameter reinforcing, such as ½-inch re bar, so that 1) any exposed by cracking will last even if it rusts, and 2) the dry mix required can be forced past it to fill the form.

Expect some cracks--Weak, wet mix hardens so that cracks don't show (at least until long after the contractor is paid); but high-strength, low-water concrete mix will show cracks quickly, and in large bulkheads cracks are inevitable. Usually they do not spoil the work. A concrete seawall will crack into sections, but each section is like a huge boulder precisely keyed into its neighbor, so the wall remains strong (though less so than without cracks). Good design allows for some cracking.

4. Stone

Excellent bulkheads can be built of large stone, but vertical structures will be very expensive. Sloped bulkheads (no steeper than 45 degrees) can be least expensive of all possible bulkheads, if the stone is just tumbled into place.

Tumbled stone will not resist wave action if the stone is small. Grapefruit-sized rock will do the job on the shore of a pond or small lake, but watermelon-size is necessary to resist any storm waves. On a bay or ocean, minimum stone size should be much larger, perhaps as large as an over stuffed chair (over 1000 lb. each). The largest stones should be placed at the bottom.

Rectangular cut stone is the ultimate bulkhead material if footing is solid. It is highly permanent and strong. It will sink through soft material such as clay until it rests on a truly hard layer that water can't soften. An engineer can easily check the load capacity of doubtful ground.

Only large stone should be used and moved by a crane or excavator. Large stone cannot be used to build a tall, narrow wall without risk of its buckling outward. At least half the rocks should weigh 2 tons or more, and some 3 or 4 tons, to assure that the wall will stay in place on the strength of its weight and interlocked square shapes alone. Transportation cost is very high for such cut stone and usually pushes total cost out of reach, but great permanence will make such a bulkhead cost- effective with a pleasing natural appearance.

Concrete blocks, usually 1 yard (about 3700 lb.), can be substituted for granite, and are sometimes available cheaply. If so, check the concrete's quality, especially moisture content when poured, and use the same criteria as for poured bulkheads as described above.

C. ADDITIONS

Increasing the size or length of a bulkhead is usually unwarranted. If the goal is to stop erosion and the existing wall fails to do so, probably a bigger wall will not help. If the goal is to create additional usable space, other solutions have less environmental impact and lower cost.

1. New Design or Materials

A simple lengthening may benefit from a change in materials and design. For example, a crib bulkhead is extended better using tumbled stone or poured concrete (correctly mixed--see IV.B.3. above). A vertical wall can be lengthened with a sloped bulkhead (see Section IV.B.4. above).

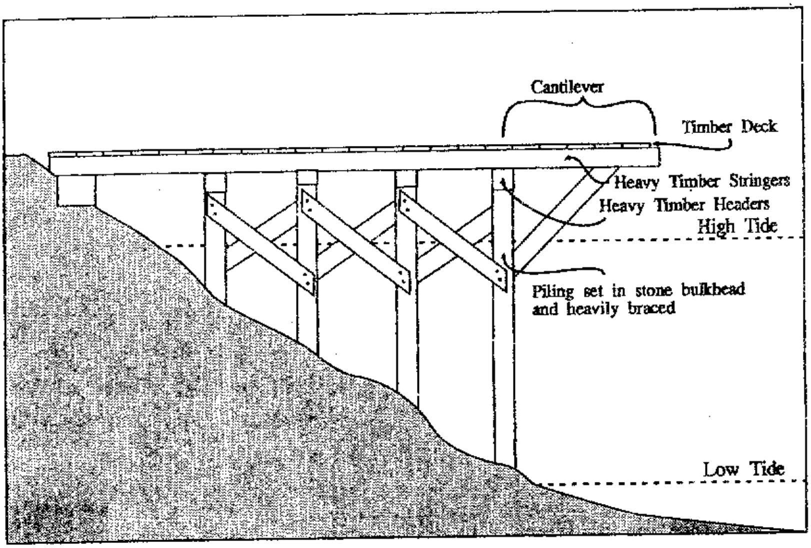


FIGURE 6: Open pile deck over sloped bulkhead

2. Cantilevers or Pilings

Additional space can be created with decking supported by a cantilever or open pilings (see Fig. 6). These structures can be placed over a sloped bulkhead (see Fig. 6) or in front of a vertical one. They can be made strong enough to support heavy machinery if needed, and have much less environmental impact than solid bulkheading, and so are more likely to be allowed by state regulation.

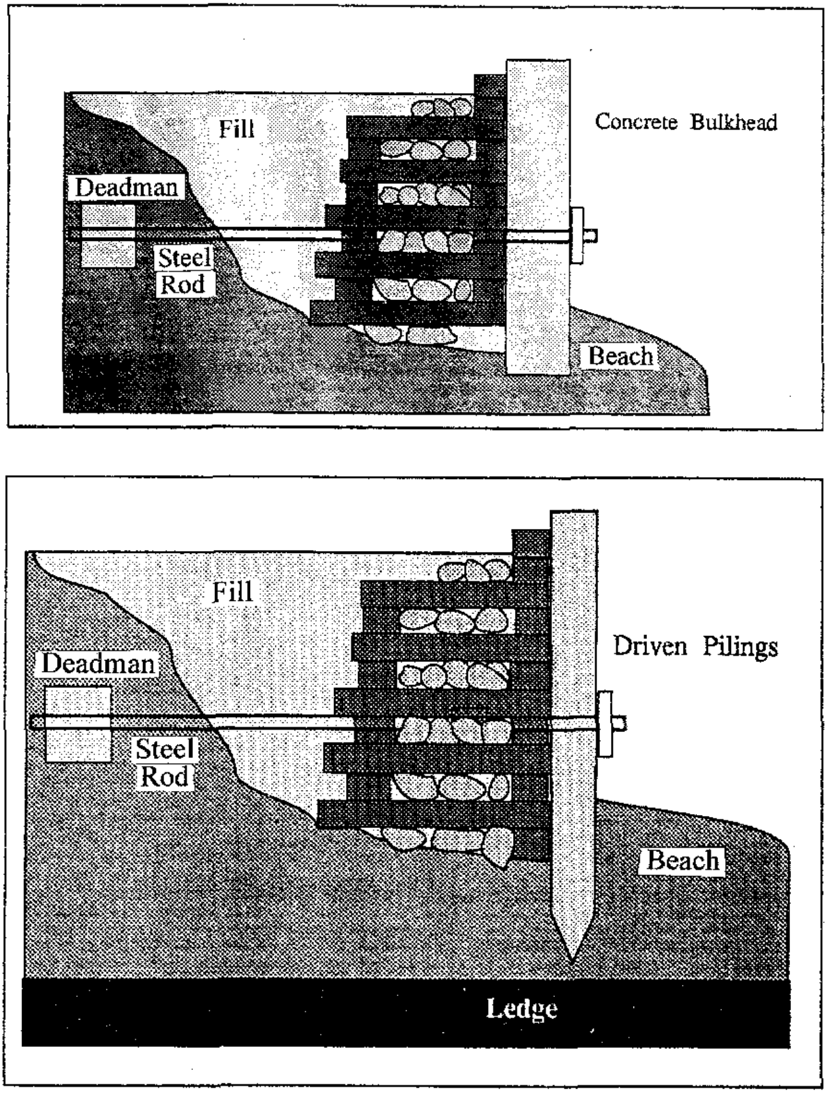


FIGURE 7: Two ways to save old cribs

3. Wetland Mitigation

Construction or repair of seawalls or bulkheads may result in destruction of wetland habitat along the shore. Check with the Maine Department of Environmental Protection (207-287-2111) for guidelines for mitigation.

D. BULKHEAD REPAIRS

Old bulkheads are difficult to repair. The following are suggestions to makes repairs more successful.

1. Do Not Wait

The most common mistake is letting bulges get bigger before repair, but meanwhile costs increase ever faster.

2. Consider Changing Methods

It may not be cost-effective to patch the old bulkhead in the same manner as it was built.

Strengthening--Sagging crib bulkheads may be salvageable by pouring a concrete bulkhead in front, or by driving pilings in front and tying back to a deadman. Both are illustrated in Fig. 7.

Replacing--Many old bulkheads are cheaper to replace than to patch extensively. Digging out the old structure clears space for new, longer-lasting materials and design.

Permitting--Changing materials, although often a better solution, may require additional permits.

Section V.

Ramps or Gangways

Ramps, also called gangways, are generally long, flat, movable walkways leading from a fixed structure to a float or watercraft. They can be made of wood, steel or aluminum. A good design is crucial for ease of use.

If ramps are to be constructed by amateurs or carpenters not familiar with marine construction problems, good plans and good advice are needed. Good design is more important for ramp building than any other type of shoreline project, because opportunities to build a disappointing ramp are abundant, especially if one tries to copy a nearby project.

A. MATERIALS

Ramps can be constructed of wood, steel, or aluminum. The advantages and disadvantages of these materials are discussed below.

1. Wood

Wood is usually the best material for ramps. It is most comfortable to walk on, best looking to most people, and, although somewhat heavier than aluminum, is lightweight enough to handle easily. The life expectancy of a wood ramp, even if untreated, is 15-20 years, because it is usually so open that it dries out after rain instead of rotting.

2. Steel

Steel ramps will work, and are usually not heavy enough to cause difficulty, but they are hard to maintain. Rust must be fought continually, and eventually it wins.

Steel ramps are best suited to facilities with a permanent maintenance person who enjoys sanding, painting, and welding.

3. Aluminum

Aluminum ramps last long unless destroyed by storms. Their shaky feeling often can be minimized by bracing or decking the walkway with wood. Their light weight is only a small advantage because any proper means for removing (see Section V.B. 6. below) and reinstalling them can handle heavier ramps just as well.

Some aluminum ramps use a reinforcing system under the walkway that interferes with dragging or rolling the ramp. This reinforcing cannot be removed, and other means of moving the ramp (for storage or repair) may have to be found.

Aluminum ramps almost always have wheels at the bottom end, making them unsuitable for the type of float system in which the ramp holds the float away from shore. A way around this problem is to use a retaining rope or chain to hold the wheels in place on the float (see Section V.B. 3. below).

B. DESIGN

Good design is the secret to the best ramp. There are many good designs, but they are outnumbered by mediocre ones, which produce ramps that are heavier or lose their shape early in life. The longer the ramp and the more exposed its location, the more critical is its design.

The best-designed ramps are long, narrow, light, and retain their shape. They are the most noticeable part of a small dock system, and the part most suited to artistic treatment. Yet they are also the most technically demanding, partly because they are little bridges that must move and flex constantly, carry large loads, but also be lightweight.

I. Length

For average tides--It is easy to underestimate required length. A 32-foot ramp, standard length for an average water-level change of 9 feet, becomes quite steep during unusually low tides (minus 1½ feet). A 20-foot ramp may be enough for a 6-foot water level change. Thus, an adequate length is about 3-½ times the normal expected water level fluctuation; but even longer is better, simply because the ramp will be less steep when the water is very low.

Handicapped accessibility is also enhanced by long ramps. A 32-foot ramp is passable by wheelchair at low tide for an average 9-foot tide, but requires helpers to hold tightly to the chair. A 40-foot ramp still provides an exciting wheelchair ride, but proves somewhat less frightening (See also V.B.1. and 5. below).

For higher tides--Ramps are seldom longer than 50 feet, which works well in a 14 foot tide. Longer ramps can be built, but weigh so much more that they need extra flotation as well as heavier equipment to haul them. For normal water level change above 14 feet, a ladder or power lift on the face of a bulkhead becomes highly advantageous.

For tides above 14 feet, **handicapped access** also becomes more expensive and difficult. However, a number of ingenious ramp designs have been developed to provide a gentle slope for wheelchair access, despite 20- to 30-foot tides. One such design uses two ramps: an upper one with legs at its lower end, so it can only drop part way as the tide falls; and a lower ramp that contains flotation, so it will ride level when the tide is high. A thorough investigation, including consultation, should allow handicapped access even with large tides.

2. Construction

Bridge truss construction makes for stronger ramps. A ramp that relies for strength on the stringers under its walkway will sag in the middle--and more so as it gets older. This makes the upper sections steeper and unpleasant to use. A ramp designed so that the frame that holds up the handrail is also a bridge truss will stay flat and feel sturdy. Several successful design concepts are illustrated in Fig. 8.

In general, diagonal members should be the strongest parts. They should be very strongly fastened, especially at the ends, which should be butt-joined so they can't stretch and allow the ramp to lose its shape.

3. Connections to Other Structures

Use connecting methods that minimize wear and maximize flexibility: the more freely a ramp can move at top and bottom, the less likely it will be damaged by storms or boat wakes. Examples are shown in Fig. 9. Location and exposure will dictate the best connecting method. It is recommended to seek help from a knowledgeable consultant for design best suited to your location.

Rollers--For large floats or float systems, rollers

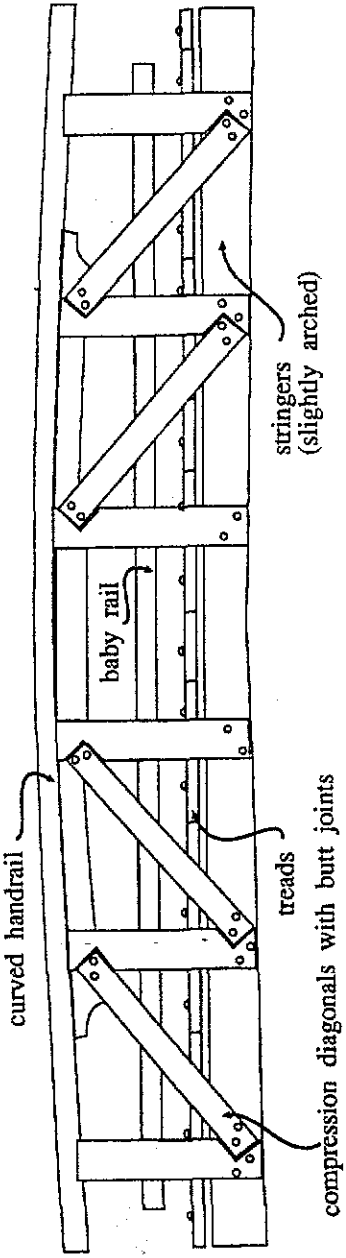


FIGURE 8: Wooden ramp design with trussed handrails

usually work well, and are better than wheels, which tend to become wobbly or wear out. Restraining lines or chains may be needed, and in very exposed areas they are essential, so the ramp or float can flex in any direction without the ramp rolling off the float.

Fixed pivots--small floats (less than 200 square feet of surface) are less troublesome if held outward by the ramp, so use a fixed pivot instead of a roller or wheels. The pivots illustrated in Fig. 9 are not completely fixed; they allow a little motion forward and backward, as well as limited side-to-side rotation. This yield prevents damage in heavy weather or if the float is struck by a boat or debris.

The open hooks or slots shown in Fig. 9 will hold a ramp in all but the most extreme storm conditions, except when the float rises higher in waves or tides than the level of the fixed shore end. Even then, the open slot may be preferable, if the ramp is allowed to leave its normal position and fall overboard rather than tear itself or the float.

4. Improvements

With careful design and construction, a wood-decked ramp can be safe to walk on, even in bare feet and when ice-covered. Some details that improve ramps are:

Foot cleats--These prevent slipping, and are preferable to friction coatings or coverings, which are very abrasive to skin if someone slips, and are completely useless when ice-coated.

Baby rails--Located under the handrail, they aid

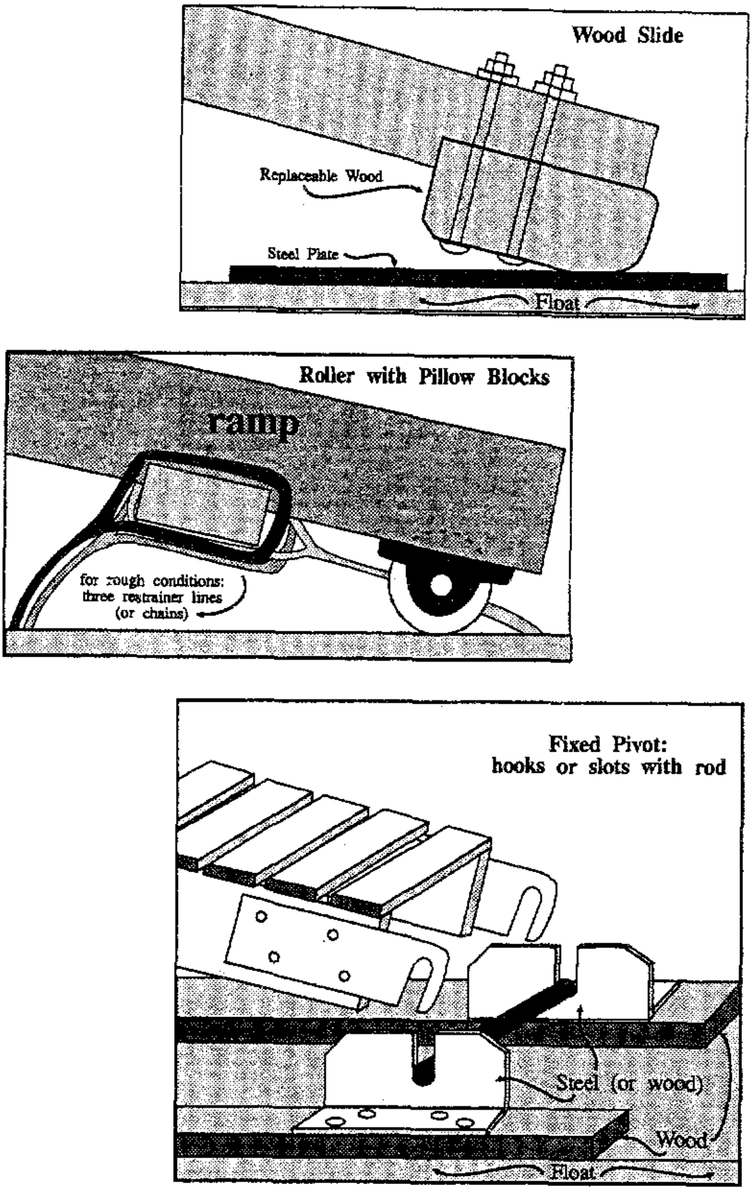


FIGURE 9: Some connecting hardware for ramps

little people and the wheelchair-bound. (See Fig. 8 above, and Chapter 5 below.)

Careful splinter hunting--Usually wood ramps are built with walkway boards cross-wise so bare feet will not get splinters from them. This practice is best, particularly for decking of pressure- treated wood, which is splinter-prone and contains toxic materials.

Longitudinal deck planks are not needed for strength in a well-designed ramp with trussed handrails. Nor are they needed to slide or roll heavy objects along them. If such activity is frequent, use an additional sacrificial layer of longitudinal planks over the portion of the walkway where objects will slide, framed by taller longitudinal boards (such as 2" x 2") to hold sliding objects in the proper pathway (see Fig. 10). This design allows walking on splinter-resistant cross planks.

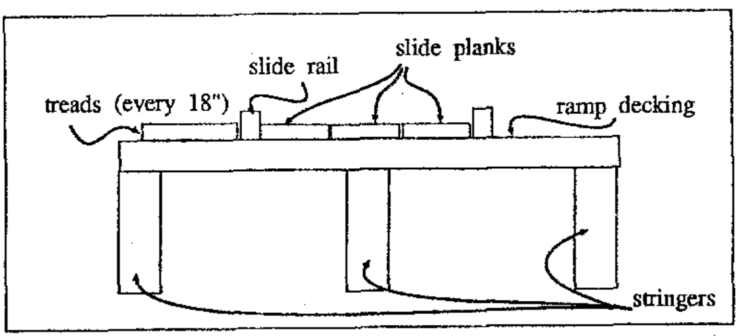


FIGURE 10: Cross section of ramp designed for sliding

Smooth understructure--This makes a ramp much easier to slide or roll, and helps prevent scarring of deck boards when the ramp is moved. Counter-sink underneath bolts, and recess any cross-members; or place a longitudinal slide-board under each stringer.

5. Special Features for Special Circumstances

For extra strength or highly artistic design--Consider using a laminated arch truss, as in Fig. 8 above. Such an arch will be very strong, even when it is built of a single 2" x 4" (rather than several laminated together) provided the grain is straight and similar in all parts of both arches. If laminated construction is used, rot must be prevented, either by using pressure-treated wood (which is undesirable) or by sealing the space between layers completely and permanently to keep water out.

For handicapped access--Give the ramp extra length for a gentle slope (see Section V.B.1. above). Make it narrow so the handrails can be reached on both sides, and any wheelchair can be turned toward either rail to check its progress. Fasten a "baby rail" (see Fig. 8 above) to the ramp's uprights at axle height for the wheel to bite when turned, and to help the operator stop for a rest.

For severe exposure--Given special attention to shock-absorbing and restraining, a ramp and float can be maintained in rough conditions--nearly green ocean. The ramp must be able to twist and flex in any direction at both ends, so the float can respond to heavy wave action without breaking.

Ramps or Gangways

The simplest way is to connect ramp to float using a roller or wheels, plus restraining lines in three directions, at about 120 degrees from each other, or in four directions at 90 degrees. This keeps the end of the ramp at the same spot on the float (or pier), while allowing it to turn. (For more detail, see Fig. 9 and Section V. B.3 above.)

Shock absorption can also be provided by restraining a ramp with nylon or other elastic line, but chafing must be avoided. Some travel can be allowed in the restraining system so that normal friction will help absorb shock, but when the travel runs out some shock will occur, particularly if chains are used. Some applications allow the use of whole or partial rubber tires. Any wood structure is itself a shock absorber to some degree, but not enough to prevent damage in rough water.

The perfect, cost-effective shock-absorbing system for ramps has not been created. For this reason, most rough-water systems use some sacrificial friction, such as wood on wood or wood on steel plate (Fig. 9), to dampen the battering effects of waves. This works well enough, but requires continuous inspection and yearly maintenance, which usually consists of replacing all the sacrificial parts.

6. Removal and Winter Storage

Gallows frame--Ramp removal can be made easy by using a gallows frame (Fig. 11). Normally, ramps for small systems are pulled with a come-along onto the fixed walkway, which is a good storage location because the ramp adds weight, and therefore security, to

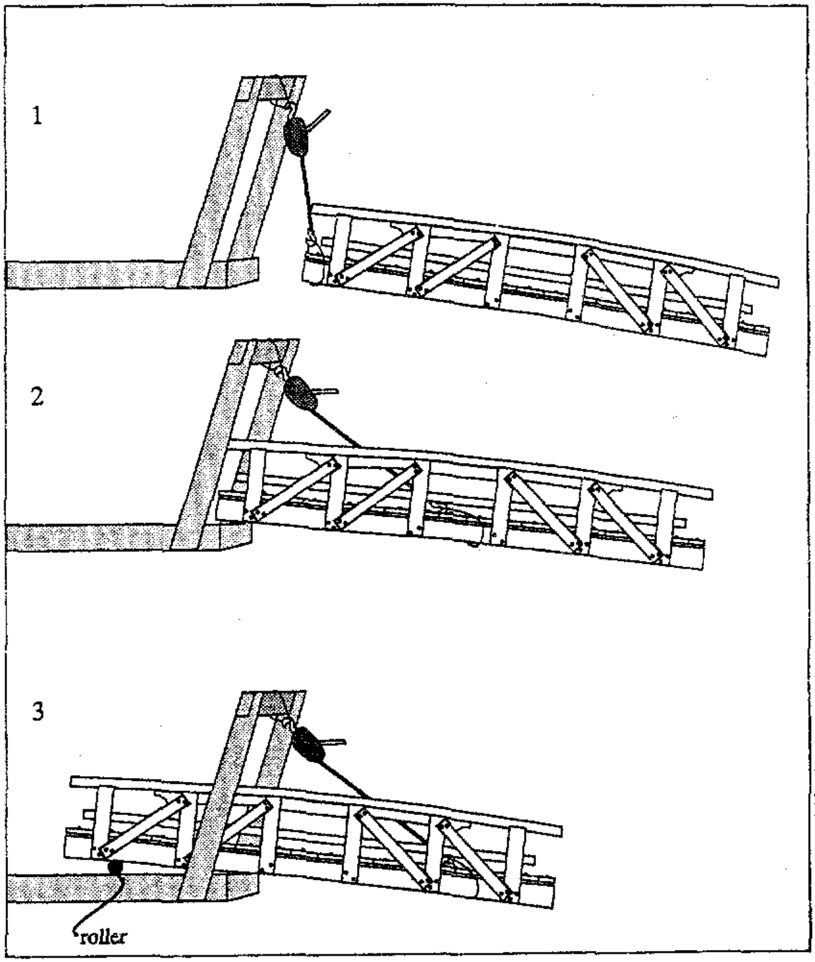


FIGURE II: Use of gallows frame and come along to haul out ramp

the pier for winter.

Storage on the float also works well, provided the float is large and the ramp has wheels or a roller at its end so that when the ramp's upper end is lifted, the lower end will slide across the float. Here also a gallows frame is the key to easy movement, and care must be taken to avoid scarring the float. If the float must travel over the shallow water to reach its winter storage, added weight from the ramp may interfere with the movement. (For landside storage, see Section VII.C.5.)

Crane--A crane is an ideal method to lift floats and ramps if you can afford the cost. Generally, having a lift method that anyone can use anytime assures better preparation for storms and reduces scheduling problems.

Counterweights--Counterweighting is effective, though initial cost is high. This makes the ramp lightweight at the outer end, allowing it to be lifted out of harm's way by one person at any time. Slight adjustment to the counterweight by trial and error helps the ramp to perform as each individual desires. Often space and location problems seem to prevent counterweighting, but a clever designer may be able to solve them. Very wide or very long ramps can be counterweighted, (at a price) using methods employed for automobile ferry loading ramps.

Section VI.
Floats

Floats, or floating portions of dock, are used for tying up boats, temporarily storing gear, fishing, sunbathing, and other uses similar to those of docks. Floats may be used separately from a fixed structure, or moored to a dock to extend its usable area.

Floats are destroyed by three factors: marine worms, rust, and fresh-water rot. Flotation failure, though also common, is not usually fatal, and damage from storms or weak construction is rare.

Design of floats is less critical and more self-evident than that of ramps or fixed piers. A great variety of good designs exist, each with particular strengths. Wood is the preferred material for walking surfaces of floats, as it is less slippery than aluminum and less abrasive than concrete. To provide flotation, closed-cell foam is most popular, and air-filled plastic containers are second choice. There is no rule or formula for selecting materials, size, or shape of floats. Each characteristic presents its own considerations.

A. SIZE, SHAPE, & WINTER STORAGE

To determine the best size and shape for a float, consider:

- how and where it will be stored for winter,
- whether boats will be stored on its deck as well as pulled alongside,

• whether it will be used for fishing, swimming, or sunbathing,

• whether there will be future increases in the number of persons using the float, and

• whether you prefer the comfortable stability in rough water of a single large float, or the easier winter storage of small floats.

1. Winter Storage

Generally, people underestimate the difficulty of moving a float up on land for winter storage. As a result, sometimes floats are not removed for the winter, in which case they can be any size.

Ice does not usually damage a float, unless the ice becomes thick enough (more than 3 feet) to compress severely, or unless the ice moves. Travelling ice cuts and crushes everything it touches, even when it is very thin. But still ice usually contains enough fractures to destroy its crushing power, especially in salt water.

Winter storm damage also occurs, though very rarely. Damage often results from strain and distortion of the float while hauling it out. Nevertheless, a float left in the water is more vulnerable to heavy damage than one that is pulled out.

One successful compromise is tying up the float to shore at extremely high tide, if the location is protected from shoreline piles of travelling ice. However, floats should not be stored on wetlands. (For storage on land, see Section VII.C.5.)

2. Size

The troubles of winter storage aside, most people feel their floats are too small, and the ideal size then becomes a compromise between use requirements and cost. An 8 x 12-foot float is adequate for a single family that plans no on-deck boat storage and berths a boat less than 24 feet long in sheltered water. In rough water, a float needs to be ¾ as long as the boat lying alongside.

A 20 x 40-foot float is adequate for an association of fifteen families with ten small boats stored on a rack in the float's center. Such a float is difficult to haul out, but can be tied up at high tide for winter.

NOTE: A seasonal or permanent structure located below the low water mark and larger than 2,000 square feet used for commercial fishing purposes or larger than 500 square feet for any other purpose will require a lease or easement from the Bureau of Parks & Lands (BPL) in the Maine Department of Conservation. For more information call BPL at 287-3061.

3. Shape

Long, thin floats (such as one 6 x 32-feet) provide more edge for tying up than squarer models. They are very stable in waves travelling from end to end, but are wobbly in crosswise waves, unless several floats are firmly fastened together end-to-end (see Section VI.E.2, below).

B. FREEBOARD

Freeboard, or deck height above water, of lake or river floats is adequate at 4 inches. Most floats have 7 to 14-inch freeboard. In general, a freeboard of 7 inches will keep your feet dry in harbor or bay breezes

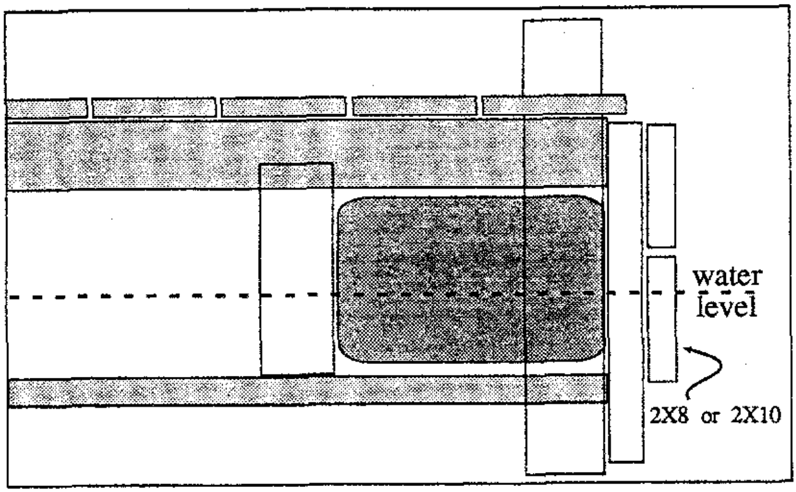


FIGURE 12: Cross section of wood float showing skirting to prevent fuel damage.

generated by strong afternoon sea breezes. An 11-inch freeboard is plenty, even in storm waves.

Some marinas allow 11-inch freeboard, others insist on 22-inch. Rough-water floats for very large vessels may even require 36 inches or more. Higher floats are more comfortable for climbing in and out of large boats, but less so for skiffs and small sailboats, for which 7 to 10-inch freeboard is comfortable. When several sizes of boat are to be used, a low float serves best, with 7 to 14-inch freeboard. High-sided power boats will probably require a set of portable steps at any float.

C. FLOTATION

Materials, such as foam or air-filled containers, must be built into floats to provide buoyancy and stability.

1. Foam

Using closed-cell foam for flotation can be a disservice to the environment and a hazard to wildlife. If it is allowed to abrade away and break up, foam becomes part of our growing pool of long-lasting waste. However, if properly contained so that it is completely immobile and protected from light and gasoline, it becomes the most reliable and cost-effective flotation available. Fuel will partially dissolve any foam flotation. The more expensive "fuel-resistant" foam is merely eaten away more slowly by fuel. Skirting boards should be located at water level in all floats with foam flotation, as shown in Fig. 12, to keep fuel spilled in the water away from the foam. (Preventing all fuel spills makes sense for environmental as well as practical reasons).

2. Plastic barrels

Plastic barrels can be cheap but will only be reliable if tightly sealed and carefully defended against bumping, poking, and piercing. An extremely inexpensive float can be built with such barrels lashed to the underside of a wood deck. The result is satisfactory if the float never touches rough or abrasive bottom.

3. Thickness/Distribution

A more stable, comfortable float can be built with thinner flotation spread out horizontally. The wobbly quality of many floats results from concentrating flotation in too few locations. Imagine a float supported by a 2-foot cube of foam at each end. When a 110-pound person steps on one end, the float will sink 6 inches. The same float supported by a thinner, wider sheet of foam (6" X 4' x 4'), will only settle 1½ inches, and thus feels more stable.

Foam for flotation is sold in billets, usually 7" or 9½" X 20" X 96". These lend themselves well to good horizontal distribution as described above. Most hard plastic flotation is more chunky in shape, and those that lack foam filling may crack and fill with water.

4. Quantity

Quantity of flotation is even more important than distribution in determining float stability. Simply, more is better.

For example, the average small float will ride at a comfortable freeboard while carrying half the weight of its ramp (about 450 lbs.), and four people (about 600 lbs.). The average wooden 8 x 16-foot float weighs about 2000 pounds, and in the water half that weight is above the surface. Thus, that float needs to hold up about a ton of weight (450 + 600 + 1000 lbs.).

Four float billets (9½ inches thick) or five 55-gallon plastic barrels will do the job, but without much in reserve. With four people on the float, the foam or barrels will be nearly submerged. Thus, eight billets or barrels provide better flotation, plus greater stability because the larger number doubles the horizontal distribution and therefore halves the settling effect.

5. Tubes

Another alternative flotation material-- steel, aluminum, or fiberglass tubes, with or without foam filling--generally lasts well. Tubes of 18" to 24" diameter make good pontoons, and one along each edge of a float will provide good support. Tubes are less suitable than foam billets for small floats because of the lack of horizontal distribution, but in floats over 40 feet long they work well. Initial cost is high, and metal tubes are subject to corrosion, which adds to the cost for sealants and maintenance.

6. Concrete

Concrete flotation does work. The most reliable concrete floats are heavily built and foam-filled so that if they crack they will not sink. Their initial cost is usually high, and their weight makes them difficult to haul out. But they are built of a material that, if properly mixed and poured, will last many decades.

D. CONSTRUCTION METHODS

Construction techniques can minimize float damage from rot, marine worms, storms, and general wear and tear.

1. Underwater Portions

All wood or metal that will be under water should be very heavy. Use 4- to 6-inch-thick wood. Fastenings should be of hot-dipped (not electroplated) galvanized steel or better, and at least ½ inch in diameter. Fasten generously, but avoid locations likely to split the wood, such as near ends of boards and timbers.

2. Worm Damage Prevention

Where marine worms are active, massive wood such as 12" x 12" will take worms many years to destroy. Worm shoes (sacrificial thinner bottom layers) distract the worms and delay their eating main timbers. Storing the float at or above high water level in winter allows the worms to be killed by freezing and thus slows the rate at which timbers are destroyed. A new crop of young worms will establish the following summer, but they are smaller than year-old worms, eat less, and leave smaller tunnels.

3. Rot Prevention

All wood located above the water should be as open as possible, so air can circulate to prevent rot. Deck boards should be spaced ½ inch or more apart so that debris will not accumulate in the cracks and trap moisture that leads to rot. They should also be placed appropriately so they do not "cup".

4. Flexibility

All floats flex in wave activity. Build them so flexing won't damage the float. Use many fastenings, including bolts, but use a variety; a combination of bolts and spikes is better than all bolts.

5. Availability of Materials

Fastenings must resist corrosion, but they must also be readily available for purchase. Avoid using plates or brackets that must be ordered or custom-made. That way, when a fastener breaks or weakens, or when a new sister float is to be built, all fastenings will be available off the shelf at a local vendor.

E. MULTIPLE FLOATS

To expand a float area, two or more floats can be attached together and pose new challenges.

1. Vs. a Single Float

Multiple floats hitched together ride waves less comfortably than one single float. Connections between floats wear out more rapidly than the floats themselves, and they can break apart in storms. Thus, multiple floats are preferred only for ease of hauling out for repairs or storage. If a system will not be hauled out for winter, a single large float is the most user-friendly. It can be made any shape, including boat slip "finger", and can be designed to unbolt into sections for repairs or maintenance.

2. Connecting Multiple Floats

Floats can be attached tightly together, or loosely with space intentionally left between them. Either way devices connecting floats need careful planning, because they are often strained by strong forces. Connectors are the first part of a float to have trouble, and the only part to need maintenance while floats are in the water.

Tight connection method--Usually in this method when fastenings fail it is because they loosen, so that the two floats can yank and wrack each other in waves or wakes. This action can further loosen fastenings, split the wood around them, snap steel brackets, or bend steel pipes and rods. Keeping fastenings tight as regular maintenance prevents this kind of damage. If bolts or eyebolts are used, they should have access holes or removable deck boards so the nuts can be tightened, and they should be double-nutted to prevent unwinding. Double nuts are the simplest and most reliable method; avoid lock washers or other extras.

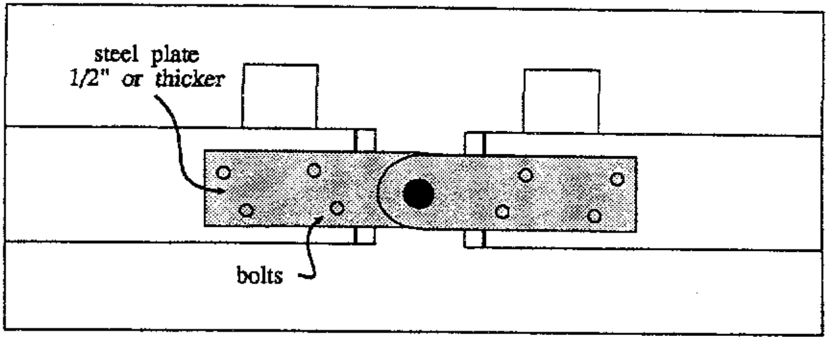
Bolts are usually the only fastenings to use to connect floats tightly. However, in extremely well-protected locations, lag screws will work, provided the wood is massive enough to give screws plenty of grip.

There are two adequate, common methods for tightly connecting floats: eyebolts and steel plates, both with a steel rod or pipe (Fig. 13). Both are subject to loosening, but will last better and loosen less if supplemented with shock absorbing material. In rough-water locations, a pair of floats that regularly tear apart at the connection will cease to do so altogether if cushioned in this manner.

Loose connection method--An excellent alternative to tight connection, is mooring the floats several feet apart (Fig. 14). The system is completed with connecting lines or chains, crossed in an X to prevent sideways drift, plus a simple wooden platform bridge that is removable for winter storage or repair. This setup offers many advantages, including greater surface area, lower maintenance cost, better storm damage resistance, and longer perimeter for tying up boats.

The space between the floats can be 6 inches without a bridge, but including shock absorption; or it can be up to 12 feet with a bridge. The system (shown in Fig. 15) using a narrow space is the cheapest, simplest, most easily maintained of all, and is the best system for large floats.

One disadvantage of loose-connection is that it



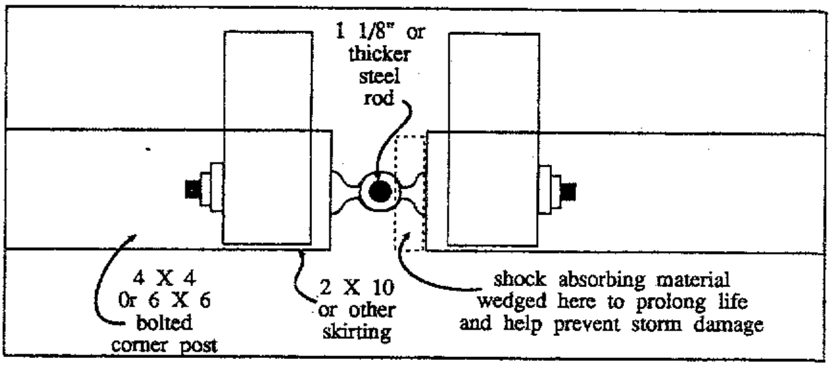
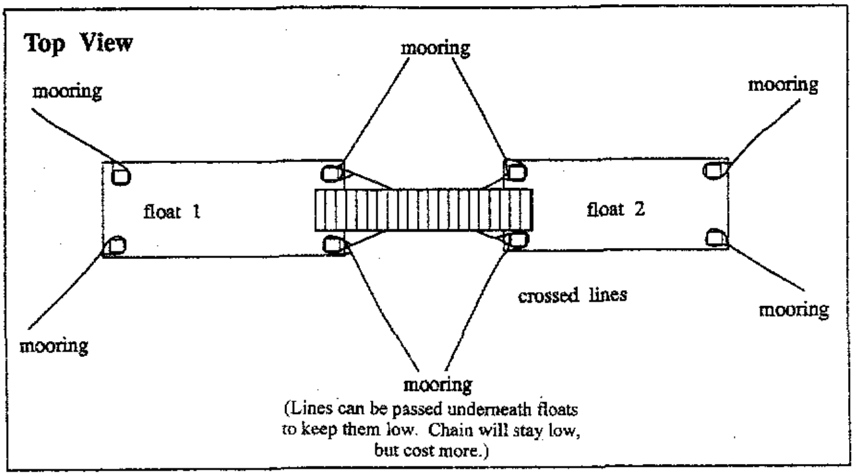


FIGURE 13: Two methods of light-connecting floats

does not lessen wobble, and the smaller or narrower the floats, the more important this is. Tight connecting allows several small floats to resist side-wise wobble as if they were large. For this reason, floats smaller than 150 square feet should be tightly connected.



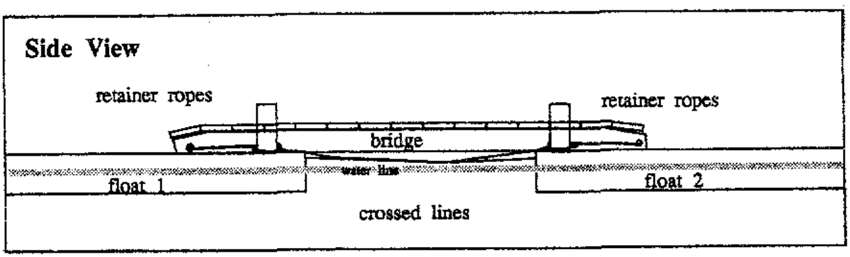


FIGURE 14: Separated Floats

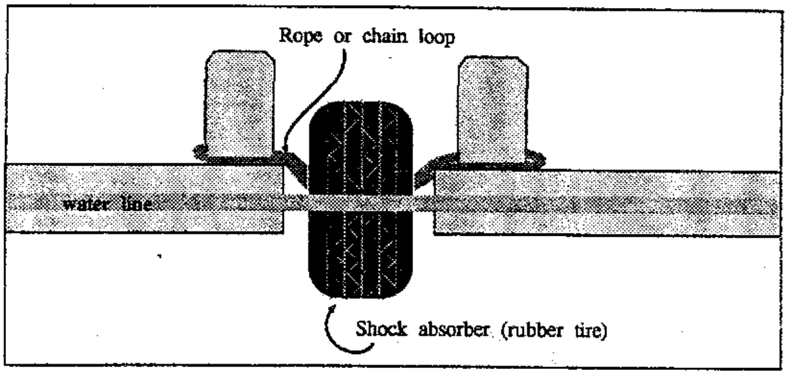


FIGURE 15: Narrow spaced float separation

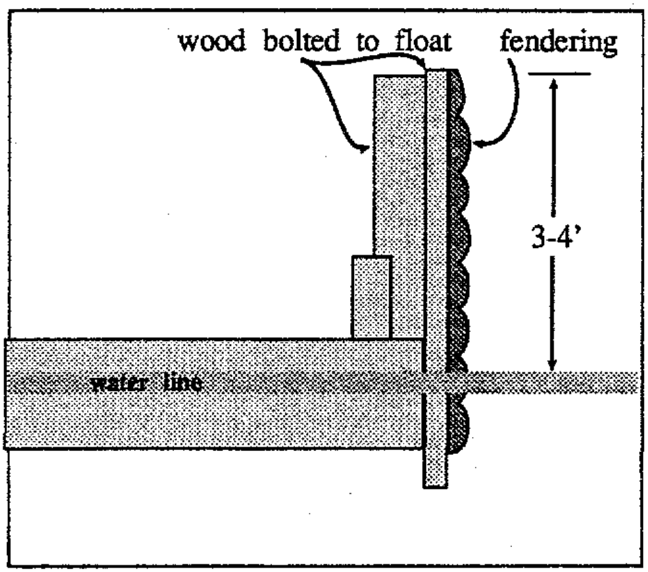


FIGURE 16: Fender Posts

1. Fendering

To prevent friction damage between floats and boat hulls, attachment of fendering materials may be required. Unfortunately, available fendering materials are costly and short-lived, though less aggravating than scratches in boat hulls.

The best fendering for a boat berthed at a float is air-filled balls or tubes hung from the boat. But when landing and leaving a float, the fenders tend to move out of place. An excellent alternative or supplement to the usual horizontal float fendering is vertical fender boards (Fig. 16). These allow boats to rise and fall in large waves without damage. Thick fenders also prevent cruising damage from oversized wakes or poorly executed landings.

2. Securing Floats

Type--Floats can be anchored to mooring shore pins or pilings.

Moorings have the advantage that in storms the floats are kept from smashing on the shore. Moorings will hold a large float or system of floats without excessive flexibility. Combined with lines to shore, they hold very reliably, and allow only 1-2 feet of movement. They will hold whole marinas, even those with thousands of linear feet of floats.

Shore pins or posts (or trees), however, need no maintenance under water, and cost less than moorings. Used with a fixed pivot ramp that holds the float away from the shoreline, (Fig. 17), they will endure severe conditions, but not major storms which place excessive strain on the ramp.

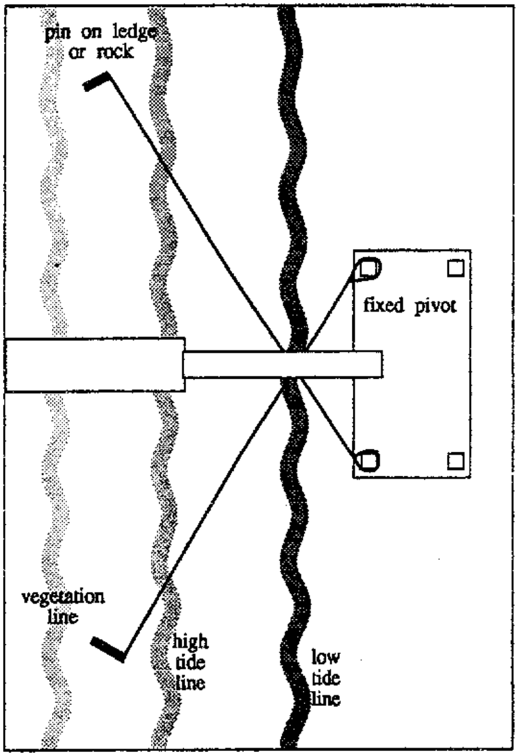


FIGURE 17: Securing float with shore pins

Pilings are the most expensive means of holding a float in position, as they must be placed using special equipment. They are also not the best method because they lack flexibility, holding the floats too rigidly in position.

Mooring rigging--Float moorings need not be rigged with chain, a very expensive and rust-prone connecting material. Synthetic line works well; it absorbs shock, lasts much longer than chain, and costs much less. To keep it away from propellers, run it from the mooring, underneath the float, and attach it to the float's far side; then weight it.

Mooring blocks--Mooring blocks should be much heavier than an equal volume of water, because once under water the blocks weigh much less. Granite provides such weight for reasonable cost. Concrete is less desirable because it is lighter, but is adequate if the mix is very dense with very low initial water content. A small (100 sq. ft.) float requires only 100-lb. anchors or 500-lb. block moorings, while a large float system may need as much as 5000 to 15,000-lb. blocks. Local knowledge is the best guide to mooring size, because bottom conditions are important to consider.

3. Legs

To allow for falling tide, legs can be placed under a float (but attached to its sides so they can be removed for hauling). Such legs will allow a float to settle level and untwisted by contacting the bottom in only a few places and conforming to irregular bottom (Fig. 18).

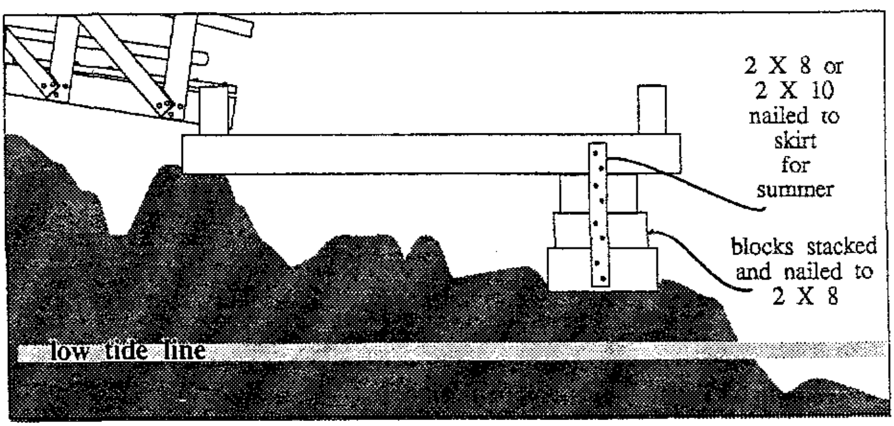


FIGURE 18: Conforming a float to a rough bottom

With such legs, a float may ground out on ledge, or even half on rocks, half on soft mud.

Any portion of a float that rests on mud can safely berth a boat, even in rough weather, though not in storm conditions; boats that settle onto mud usually remain undamaged.

Notes:

Section VII.

Landside Issues

Adjacent upland areas can suffer major impacts from waterfront access facilities such as docks and piers. This section addresses design and construction of needed land-based facilities, such as parking areas, access roads, paths, and public buildings. These guidelines are particularly relevent to the design of public access facilities.

A. SITE CONDITIONS

The most important approach is to plan ahead to minimize changes to the site and limit impacts of necessary activity. This preserves existing environmental values of the site, while enhancing its use as waterside access. In general, steps should be taken to minimize the possibility of erosion during contruction and use. These measures, called best management practices (BMPs), include the use of straw mulch over bare earth and maintenance of vegetated buffer strips along the shoreline. BMPs are ususally described in and required as conditions of DEP or local permits when working in environmentally sensitive areas.

I. Aesthetics, how it looks

Site preservation--Do everything possible to enhance the beauty and character of the site without altering it.

Orientation--Try to orient facilities to take advantage of sun, shade, breezes, and protection from storms.

Scenic views--If there are particular areas or corridors of scenic value, preserve them by minimizing obstructions, encouraging people to observe them (such as with point of interest plaques), or creating a pedestrian path to an existing clearing.

2. Vegetation

Preservation--Removal of existing vegetation (trees, shrubs, or ground cover) should be minimized. Some overstory clearing can be appropriate in situations where a good ground cover exists and there is no erosion potential.

Native plants--If a site is to be finished with landscaping materials, select plants that are already found on the site (native). Only native species should also be used both to revegetate areas and to provide suitable conditions for proper plant growth.

Ground cover--Ground cover plants other than lawn should be used where an open area is planned, reducing the need for mowing.

3. Drainage

General guidelines--A proper site drainage system provides many benefits: it keeps the site usually well-drained; increases the site's lifespan; limits nonpoint source pollution of the waterway; and reduces siltation of the water body, thereby lessening the need for dredging.

Providing for the drainage of rain and snowmelt across the site should be an integral element of any plan. Use existing land contours where possible to aid in the flow of runoff. Water should flow readily from land to drain system without causing erosion or deposition of silt.

Runoff control systems--Storm water runoff from the site should not be discharged directly into adjacent waters under any circumstances. Storm water control systems include catch basins, culverts, drop inlets, swales, etc.

Surface water should be held on the site in catch basins, ponds or filtration pits. Swales or ditches can be used to carry water to catch basins. If a site is connected to a storm water drainage system, drop inlets can be used to allow runoff to be centrally collected and flow underground to be treated. The drainage system should provide adequate capacity to carry and hold the flow.

Plantings as fillers--To limit nonpoint source pollution, it is best not to allow water to run off directly into a waterway. Plants that form dense canopies and have deep roots (trees and shrubs) can be used to trap runoff best and extract water from the soil (see Section VII.A.2 above). Direct drainage into natural buffer areas where possible.

Snow removal--If snow is to be removed, it should be dumped in a location where road salts and oils do not drain directly into the water.

Construction methods--Construction and maintenance should use a minimum of heavy equipment. Plan the project to take advantage of smaller types of construction equipment appropriate for tight spaces.

Wetlands--Alteration of wetlands should be avoided. State and/or local permits are required for most alterations of wetlands. If filling is absolutely essential, then the fill must be the absolute minimum necessary to build the facility, and the state requires appropriate compensatory measures.

B. VEHICLE AREAS

Parking areas for cars and other vehicles can take up a great deal of land area in a project. The following guidelines for access roads and parking areas help provide for long facility life, ease of use, and minimum environmental impact.

1. Access Roads

Signs--The entrance to a public access area should be indicated by signs placed along the closest public road, ¼ to ½ mile before the turn in either direction.

Turning lanes--The need to provide a left turn bay or deceleration lane for traffic entering the access road should influence the location of the intersection.

Road width--The access road should provide two travel lanes, typically totaling 20-24 feet wide, although a one-lane road (12 feet wide) may be adequate if wide shoulders are provided for passing and emergency parking.

Road slope--The road should have a maximum 10 percent slope or grade and should follow the contours of the land.

Road drainage--Drainage should be accomplished by crowning the road (1 percent for paved and 2 percent for unpaved or permeable surfaces). This allows water to run off and percolate into grassy swales. Culverts can also be used that accommodate the drainage pattern of the site (see Section VII.A.3 above).

Seasonal road surfaces--To maintain a good seasonal roadbed, 3 to 12 inches of gravel, crushed rock, or crushed shells make excellent surfacing materials.

Year-round road surfaces--Year-round public access roads should be underlain with filter fabric to stabilize subsurface soil, a 4-inch base of materials (as in f. above), and a final paving treatment of approximately 2½ inches of asphalt or concrete. This surface should provide a life expectancy of 15 years.

Overhead clearance--Trees, power lines, and other overhead structures such as gateways, bridges, or overpasses should be built or maintained with a minimum clearance of 13½ feet.

2. Parking Areas

Location--The parking area for a public access site should be set back an adequate distance from both the main road and the water (75-100 feet).

To protect water quality, the local ecosystem, and visual aesthetics, the area should be sited in a way that leaves a buffer of vegetation encircling the area and saves major trees and bushes (see above, Section VII.A.2).

Traffic circulation--The number of parking spaces should be determined by the use of the site. Include the appropriate number of handicapped spaces.

It is more manageable to break up parking areas into several small lots of 10-20 spaces each. This way, areas can be apportioned among types of vehicles, or closed off when not needed. Small lots can be screened from others by vegetation, which also slows runoff thereby filtering pollutants. Consider the use of "Grass Crete" or other similiar paving products which allow grass or other vegetation to grow between a lattice of concrete.

It is also recommended to designate a portion of the parking spaces for compact autos, recreational vehicles, and motorcycles. Camping vehicles should have a separate area.

Auto spaces should measure a minimum of 10 x 20 feet (or 15 x 20 feet to accommodate handicapped users). Spaces for vehicles towing travel trailers or boats should measure 10 x 50 feet (or 15 x 50 feet for handicapped access).

Allow for vehicle/trailer movement by using a 45- or 60-degree drive-in/back-out design and some one-way roads. For maximum safety, avoid conflicts between pedestrians, unloading vehicles, and traffic. The circulation pattern should be clear and easy to follow.

Materials--The parking area should be surfaced with ground cover plants, grass with paving bricks, gravel, crushed rock, cinders, or crushed shells at a depth of 3 to 12 inches. Impervious surfaces such as concrete or asphalt should be kept to a minimum to decrease runoff of pollutants. If necessary, year-round facilities could use a 4-inch base material with a final paving treatment of asphalted concrete.

C. BUILDINGS

If structures are needed for best use of the waterfront access site, they should be designed to blend with the natural surroundings and constructed to minimize their impact on nearby land and water.

1. General Guidelines

Orientation--Structures should be oriented and set back from the shoreline; to take advantage of sun, shade, and protective vegetation; to be easily accessible from parking areas; and to fit into the contours of the site. Check with the local code enforcement officer for the minimum allowed setback required by municipal shoreland zoning ordinances.

Materials--Materials used should enhance the character of the site, be easy to maintain, and be readily available.

2. Information Kiosks

Location--Kiosks should be central to all activities.

Design--The facade should accommodate dissemination of information and encourage response from user groups.

3. Restrooms

Availability--Public restrooms should be provided on site for public and commercial facilities.

Type--There are four major types of units: flush, chemical, vault, and composting.

Flush toilets are the best choice at large, staffed facilities. They can be expensive to construct because a water supply and sewer connection are needed. If sewers are not available, a septic tank/leach field can be an alternative. However, the soil must test to the appropriate permeability, or effluent from the leach field will find its way into the water body nearby. Facilities that can be connected to public water supplies provide the added benefit of public drinking fountains on site.

Chemical toilets are hard plastic units that are self-contained (such as Port-o-Sans). They have the advantage of portability and are commercially available for purchase or rental (many rental agreements include regular maintenance).

Vault toilets consist of a fixture mounted over an underground concrete vault to hold the sewage until it is pumped out (as in outhouses). These units are well suited to remote or low-use facilities. Though they sometimes have an odor, adding solar vents can reduce the odor by speeding decomposition.

Composting toilets (such as Clivus Multrums) are the best alternative to avoid using chemicals. Depending on the type of unit, maintenance can be minimal. These are sometimes the only permanent option in coastal situations with bedrock or ledge.

Appearance--The building that houses the restroom facilities should be attractive but sturdy and vandal-resistant.

4. Shade/Rain Structures

General--To best apply limited funds, structures on the site to protect users from the sun and rain should be treated as amenities and provided only after meeting the basic needs such as restrooms and properly built parking areas.

Materials--Structures should be of simple wood construction. Often, materials such as wood or stone are produced when clearing the site, and are thus convenient as well as attractive.

Design--The design should be in character with other improvements.

Location--The structure should be oriented for the time of day it is most needed. For example, place a structure where it will catch warm morning sun, but cool afternoon shade of deciduous trees.

Roofing--The roofing material could indicate the intended use of the structure, such as an open slatted roof for shade only. However, a shingled roof can serve as both shade and weather protection.

5. Storage

Design--The facilities should be designed to accommodate any necessary indoor storage (brochures, equipment, materials, etc.).

Gangways and floats--Gangways and floats can be stored in parking areas, unless the facility is for year-round use, where a separate area should be reserved for their storage. Under no circumstances should storage occur on adjacent wetlands.

D. SITE IMPROVEMENTS

Waterfront access sites may include improvements such as park furniture or night lighting. These should be designed to be unobtrusive while functional. Solid waste management is also essential to providing a pleasant experience and reducing litter.

1. Pathways

Old paths--Existing paths should be improved first, rather than building new ones, unless slopes on existing paths exceed 1:12 (1 foot rise to 12 feet run).

New paths--If a slope exceeds 1:12, there is potential for erosion and the path will not be accessible to everyone. Existing contours should guide development of new paths.

Construction methods--Improvements to paths should be undertaken in the least destructive manner possible, by using manual methods rather than machines. Recommended surface materials are shown in Fig. 19.

Wooded paths--Woodland and forest materials, such as leaf mold or pine needles, should be used to cover bare ground. Exposed soil or tree roots indicate overuse and/or erosion. Worn paths should be rehabilitated by covering with this mulch; defining borders with logs, stones, or ground cover; and/or other erosion control work.

Paths in the open--For pathways that are developed across open areas, a sand base with finely crushed stone (stone dust) is most appropriate. To define the path and discourage wandering off the path, medium-sized stones can be used to line both edges.

2. Park Furniture

Location--Areas along pathways or in natural clearings should be designated for furniture.

Security--Furniture should be placed in areas of the site to minimize theft, or bolted into concrete blocks buried in the earth.

Materials--On certain sites, furniture can be built out of natural, on-site materials such as granite slabs.

3. Lighting

Use--Sites should be area-lighted only if the site is to be used at night and electricity is readily available.

Type--When other power sources are not on site and area lighting is desired, solar cell lights can be used.

Marine locations--Lighting of docks, piers, or wharves should be handled by low-watt marine fixtures.

Characteristics of Soft Surfaces for Walkways

Crushed Rock	• irregular surfaces make walking extremely difficult for people with mobility handicaps.
Earth	• surfaces are poor for wheelchairs and other small-earth wheeled vehicles.
Grass-Lawn	• surfaces give the blind difficulty with orientation.
River Rock	• surfaces are susceptible to erosion. • surfaces will withstand only light traffic.
Soil Cement	• surfaces are useful for areas where light pedestrian traffic will need a moderately firm surface.
Bark	• high maintenance requirements, low installation costs.

Characteristics of Variable Surfaces for Walkways

Cobblestones

Exposed Aggregate

Flagstones

Sand Laid Brick

Wood Deck

Wood Discs in Sand

• irregular surfaces and wide joints make walking extremely difficult for people with mobility handicaps.

• joints easily trap crutch and cane tips, heels, andnarrow wheels. Joints should be filled and no wider than 1/2 inch.

• irregular surfaces make movement difficult for wheel-chairs and other small-wheeled vehicles.

• ice and snow can damage the surface or be difficult to remove.

• moderate maintenance requirements, moderate to high installation costs.

Characteristics of Hard Surfaces for Walkways

Asphalt

Concrete

Tile/Brick in Mortar

• surfaces are firm and regular for walking and moving wheeled vehicles.

• joints are kept to a minimum, less than 1/2 inch wide and filled.

• ice and snow removal are possible without extensive damage to surfaces.

• lowest maintenance requirements, high installation cost.

4. Solid Waste Management

Carry in/carry out--The best approach to managing solid waste at small infrequently monitored sites is to encourage visitors to carry their trash out.

Collection--If the site is municipally maintained, the type and location of receptacles may influence their frequency of use by the public. One suggested system is to place small receptacles throughout the site with central collection dumpsters for ease of removal. Small receptacles should be chained to posts near picnic tables, benches, parking areas and/or foot paths.

The waste collection area should be convenient to the access road and parking area for ease of trash removal. Dumpsters should be located along the access road between the facility and the main roadway. Dumpsters should be oriented to take advantage of natural screening, if possible. Planting a dense evergreen buffer will reduce the visual impact and mask odors (see above, Section VII.A.2).

Recycling--For recycling purposes, solid waste should be separated on site by the user into as many categories as possible, such as glass, metal, paper, and food garbage. Many facilities direct users to dispose of non-recyclables in one receptacle and all others (recyclables) in another receptacle; later, staff separates recyclables as appropriate. To further reduce the burden of waste storage, biodegradable paper and food garbage can be composted on the site.

Notes:

Section VIII. Technical & Financial Assistance

A. AGENCIES & GRANT PROGRAMS

A number of state sources provide technical and financial assistance to Maine communities to support projects that enhance opportunities for water-dependent activities. The following list describes these programs and provides a contact person.

1. Waterfront Action Grants

Available for acquisition and development of shorefront land to improve public access; low-cost construction projects on waterfront land; and rehabilitation of municipally-owned piers/wharves. Funds for these grants has been limited in recent years. Please call the State Planning Office for updated information.

Contact: Francine Rudoff, Maine Coastal Program/Maine State Planning Office, 184 State St. Augusta, ME 04333, 207-287-3261.

2. Growth Management Implementation Grants

Available to municipalities that have submitted a comprehensive plan as part of the state growth management program. These funds are intended to carry out the implementation strategies outlined in the community's comprehensive plan.

Contact: John DelVecchio, Maine State Planning Office, 184 State St. Augusta, ME 04333, 207-287-3261.

3. Community Development Block Grants

Available for downtown revitalization, housing rehabilitation, public facilities improvements, and other local programs that benefit low- and moderate-income individuals.

Contact: Aaron Shapiro, Department of Economic and Community Development, 287-8476.

4. Land and Water Conservation Fund

Available to support the acquisition and/or development of outdoor recreation facilities, including waterfront parks.

Contact: John Picher, Bureau of Parks and Recreation, Department of Conservation, 287-3821.

5. Boating Facilities Program

Available for acquisition, development, and improvement of state, regional, or local boat access sites.

Contact: Richard Skinner, Bureau of Parks and Recreation, Department of Conservation, 287-3821.

6. Wallop-Breaux Program

Available to support acquisition, development, and improvement of inland local, regional, or state boat access sites.

Contact: Department of Inland Fisheries and Wildlife, 287-5261.

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Notes:

APPENDIX I
MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION
CRITERIA FOR PIERS AND WHARVES

The Department processes a large number of applications for piers and wharves. Contact the Department to see if your project can be permitted under the 'Permit by Rule' standards of the Natural Resource Protection Act. To streamline our handling efforts and to make the process more predictable for applicants, these guidelines have been developed. Our intent is to describe design characteristics that will generally receive approval. Proposals that vary from these guidelines will require more detailed review, and will gain approval only with thorough justification of the proposal by the applicant.

A. Types of support structures:

1. Pile-supported construction is preferred over other types of construction. Pilings will have the least effect on marine resources habitat, natural flow of waters, navigation and existing recreational uses.

Piles or posts may be of metal, wood, or masonry materials, and shall be:

a) securely fastened to rock or ledge, or

b) driven either to one-third of their length or to refusal into mud, gravel, cobble or other penetrable deposits.

NOTE: Pile supported piers may be constructed under DEP'S Permit-by-Rule Program provided they meet specific standards.

2. Crib supports for piers and wharves where necessary are generally approvable subject to the general design characteristics listed in Section B. below, as well as the following specific limitations:

a. Crib supports are a form of fill and thus will generally not be allowed in if a practicable alternative exists.

b. Where cribs would create adverse effects on the flow of waters or navigation, the Department will insist upon pile-supported construction.

c. Wood treated with creosote or pentachlorophenol will not be approved for use on structures located in coastal wetland areas.

d. Crib supports exceeding 500 sq. ft. must be reviewed under the Wetland Protection Rules & may require compensation.

3. Solid-fill construction will generally **not** be approved if pile or crib supports are a practicable alternative. Compensation (mitigation) for the wetland habitat loss may be required if solid fill or large crib supports are necessary.

B. General design characteristics:

1. The length and width of structures should be the minimum necessary to accomplish the purpose; usually no more than 6-feet wide for private recreational piers

and 12-feet wide for commercial piers all above low water. Larger structures will not be approved without adequate justification. Length may be based on access to sufficient deep water.

Any accessory structures on or attached to the pier shall be included on the plans, including temporary structures (i.e. in place less than 7 months per year).

Structures shall not extend across more than 25 percent of any channel at mean low water. No structures shall extend into a designated federal channel.

2. Wharves or piers should be designed and constructed to withstand major storm events and hazards, such as a 100-year storm with winds of 80-100 mph. and winter ice conditions. Where structural integrity appears questionable for the proposed locations, certification by an engineer may be required. Attached ramps and floats should also be securely anchored.

3. Shellfish habitat or vegetated areas should be avoided. If construction in vegetated areas is unavoidable, structures shall be designed to avoid shading of vegetation, such as being at least 1:1 in height to width.

4. Power machinery or heavy equipment shall be operated from above high water or from barges, and not in the intertidal area, unless approval is granted for erosion control or mitigation plans designed to protect habitat and water quality.

C. Preservative treatment and protective coatings:

1. Any treatment of materials against deterioration must be done away from the coastal wetland area before

installation, such that preservatives, paints or debris shall not wash or fall into the coastal wetland.

2. Untreated oak pilings or timbers are preferred over pressure-treated wood.

3. Pressure treated wood if used must be air dried on all sides for at least 3 weeks prior to installation to avoid significant adverse environmental effects.

4. Waterborne salt treatments such as chromates or arsenates are preferable to oilbase treatment. Pentachlorophenol and creosote treated materials must not be utilized.

5. Initial sanding and sand-blasting, priming, painting and coating of metal components should be completed on land, prior to installation. Zinc anodes should be attached to metal posts to minimize the corrosion of metal components during exposure to seawater.

D. Siting and additional permits:

1. To prevent interference with navigation or existing recreational uses, the orientation of the pier should be as perpendicular to the shoreline as possible, and not interfere with access of others to their shoreline, moorings, or docks. Orientation may be based on access to sufficient deep water.

2. Wharves should be set back from property lines such that when boats are docked they will not be over property sidelines, blocking water access on adjacent property.

Piers, wharves and pilings shall be set back at least 25 feet from property lines and 50 feet from other structures that are fixed in place below the normal high water line and not owned or controlled by the applicant unless a letter of permission is granted by the abutting or other controlling property owner.

Sideline boundaries can be determined as follows:

An owner of property located on tidewater owns all land down to the mean low water mark or 1650 feet (100 rods) from the high water mark, whichever is less, unless specifically indicated otherwise in the deed.

i. For each property, draw a base line between the points where the property lines touch the high water mark.

ii. Project lines out from those points at a 90 degree angle from the base line and extend the lines to the mean low water mark or for 1650 feet (100 rods), whichever is less.

iii. Where lines of adjacent owners conflict, as in coves, or do not touch, as on points, split (into halves) the difference between the projected lines.

3. In addition to approval under the Natural Resource Protection Act, governmental reviews at local, state and federal levels may be required.

a. Town permits or approval may be required for piers and any accessory structures under the Wharves and Weirs Act (Title 38 M.R.S.A., Sections 1021--1027) or local Shoreland Zoning Ordinance (Title 38 M.R.S.A., Section 435) provisions.

b. Any permanent part of a project below the mean low water mark may need a lease or easement from the Maine Department of Conservation, Bureau of Parks & Lands.

c. Federal permits under the Department of the Army, Corps of Engineers, may be required.

E. Maintenance and Repair

1. Some maintenance and repair/replacement projects are exempt from general permit requirements. These fall into two categories:

a. Maintenance and repair and replacement activities which qualify under Section (4) of the Department's Permit by Rule Standards Chapter 305.

b. Maintenance and repair of structures above the high water line causing no additional intrusion of an existing structure into the wetland provided that erosion control measures are taken to prevent sedimentation of the water.

c. If the local code enforcement officer or the state geologist determines that the integrity of a seawall, bulkhead, retaining wall or similar structure in a coastal sand dune system is destroyed or threatened, the owner of property protected by the seawall, bulkhead or similar structure may initiate certain repairs without a DEP permit. The allowed repairs under this provision of the NRPA include placement of protective materials such as sandbags and strengthening of the structure by widening footings or securing the foundation of the structure with bolts.

2. The following are suggestions to avoid violation

of other environmental laws:

All maintenance or repair activities in, on or over the coastal wetland should be conducted at low tide, to prevent discharge into the water.

All debris generated during the repair or maintenance should be removed from the coastal wetland before the next change of tide and disposed of in accordance with Maine Solid Waste Management Rules.

3. For metal structures:

a. Removed paint, abrasives, protective coating debris and spillage from new coatings (primer, finish or preservative) must be contained by use of drapes or drop cloths and disposed of as described above.

b. Spray painting must be done at times of low wind velocity, of 5 knots or less.

c. New primer, finish and protective coatings must be applied sectionally to the extent that the specified drying time will be met prior to inundation by the next tidal change.

Notes: